24743

Bell Landfill Settling Companies

Feasibility Study Report Bell Landfill Superfund Site

7 July 1994

Environmental Resources Management, Inc.
855 Springdale Drive
Exton, Pennsylvania 19341

ERM

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Paul H. Woodruff

Paul H. Woodruff, Chairman

Kent E. Patterson, President and C.E.O.

AR300469

DuPont Chemicals
1007 Market Street
Wilmington, DE 19898

DuPont Chemicals

CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

For E. I. du Pont de Nemours and Company

5/2/94

Hugh J. Campbell, Jr. Date
Manager, Remediation Core Resources

GTE

GTE Operations Support Incorporated
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CERTIFICATION

We certify under penalty of law that this document and all attachments were prepared under our direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on our inquiry of the persons directly responsible for gathering the information, the information submitted is to the best of our knowledge and belief, true, accurate and complete. We are aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

For the Bell Landfill Settling Companies

A E Ludwig 4/29/94

Alvin E. Ludwig - VP - Controller Date

MASONITE

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I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and/or imprisonment for knowing violations.

Arch S. Bruntlett

Arch S. Bruntlett

Mill Manager, Towanda Mill

Title

April 29, 1994

Date

/tlw

INTERNATIONAL PAPER
MASONITE DIVISION

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EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (US EPA), pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), entered into an Administrative Order by Consent (AOC) with the Bell Landfill Settling Companies (SCs) on 11 February 1991. This Feasibility Study is submitted consistent with the requirements of the AOC.

The Bell Landfill Site is located in a remote area of north central Pennsylvania. The site consists of two former municipal landfills, with appurtenant leachate collection systems, several small debris areas, and related soil areas.

In 1992, Environmental Resources Management (ERM, Inc.) completed a Remedial Investigation (RI) of the site on behalf of the SCs. The RI and the US EPA Risk Assessment found that leachate and soils presented the primary current risk exposure at the site. Ground water presented only a potential future risk exposure at the site.

This FS was conducted pursuant to the US EPA's February 1991 guidance "Conducting Remedial Investigation/Feasibility Studies for CERCLA Municipal Landfill Sites". According to this guidance, a streamlined evaluation approach, which begins with a number of applicable technologies and proceeds through the development of remedial alternatives and the detailed analysis of alternatives, was applied. The results of this evaluation are depicted on Figure ES-1. Table ES-1 provides a comparative analysis of the above alternatives.

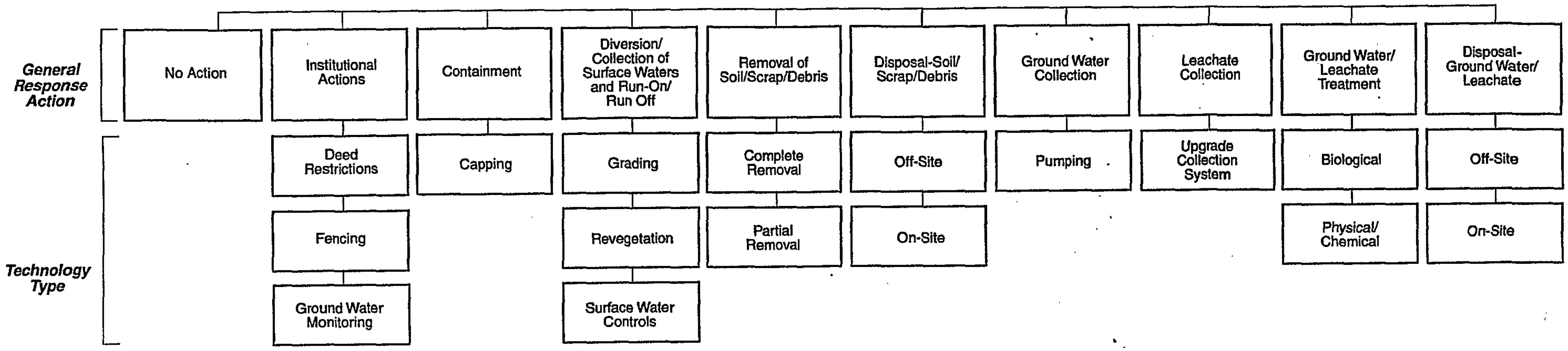
This Feasibility Study recommends Alternative 2 which includes:

- Single barrier cap;
- Leachate collection and off-site disposal;
- Consolidation of soil and wastes under the cap;
- Ground water monitoring; and
- Passive landfill gas venting and migration monitoring.

This remedy provides a level of protectiveness compliant with CERCLA, is readily implementable, and is based on a practical solution that addresses the lack of significant adverse impact/risk posed by the site, especially the lack of significant off-site ground water risk. It essentially meets the remedial action objectives to the same degree as the most aggressive remedy evaluated herein at a significantly lower cost.

Figure ES-1
Summary of Focused Alternative Development and Evaluation

Phase I - Step I - Development of Remedial Action Alternatives



Phase I - Step I - Development of Site-Wide Alternatives

Remedial Alternatives

Alternative 1: No Action
Alternative 2: Single barrier capping, on-site soil/debris consolidation, off-site scrap recycling, leachate collection with off-site disposal, ground water monitoring
Alternative 3: Composite barrier capping, on-site soil/debris consolidation, off-site scrap recycling, leachate collection with off-site disposal, ground water pump and treat

Phase II - Step I - Detailed Analysis of Alternatives

	Overall Protection	Compliance with ARARs	Long-Term Effectiveness	Reduction of MTV by Treatment	Short-Term Effectiveness	Implementability	Cost
Alternative 1	-	-	-	-	+	+	+
Alternative 2	+	+	+	-	+	+	+
Alternative 3	+	+	+	+	+	+	-

Phase II - Step II - Remedy Selection

Recommended Remedy: Alternative 2 with Value Engineered Cap

Table ES-1
Summary of Alternative Evaluation

Alternative Description	Comparative Evaluation Summary	Present Worth Cost
Alternative 1 - No Action		
• No further remedial actions • Maintenance of existing soil covers and fencing • Potential ground water monitoring	• No increased protectiveness of human health or the environment • ARARs not achieved • No reduction in existing risks associated with exposure to the site • Unacceptable to PADER	$600,000
Alternative 2 - Single Barrier Capping, Leachate Collection, and Ground Water Monitoring		
• Single barrier cap installed on lined and unlined fill areas • New perimeter drain at unlined fill area • New leachate collection tanks at both fill areas • Debris and scrap materials removed from drum and debris areas • Site graded and revegetated • Ground water monitoring instituted • Passive landfill gas venting and migration monitoring	• Existing pathways of contaminant exposure at site eliminated • Protective of human health and the environment • Achieves site ARARs • Significant long-term effectiveness and protectiveness through reduction in risks associated with direct contact • Readily implementable at site • Acceptable to PADER	$3,130,000 (2a) $2,920,000 (2b)
Alternative 3 - Composite Barrier Capping, Leachate Collection, and Ground Water Collection and Treatment		
• Composite barrier cap installed on lined and unlined fill areas • New perimeter drain at unlined fill area • New leachate collection tanks at both fill areas • Debris and scrap materials removed from drum and debris areas • Site graded and revegetated • Ground water collection with on-site treatment for organics and metals removal • Ground water monitoring instituted • Passive landfill gas venting and migration monitoring	• Existing pathways of contaminant exposure at site eliminated • Protective of human health and the environment • Achieves site ARARs • Significant long-term effectiveness and protectiveness through reduction in risks associated with direct contact • Implementability of ground water collection questionable • Acceptable to PADER	$4,600,000

1.0 INTRODUCTION

1.1 PURPOSE AND ORGANIZATION OF THE FEASIBILITY STUDY

This Feasibility Study (FS) has been prepared by Environmental Resources Management (ERM), Inc. on behalf of the Bell Landfill Settling Companies (SCs) as part of the 11 February 1991 AOC issued by USEPA. The SCs include E.I. du Pont de Nemours and Company (Inc.), GTE Operations Support, Inc., and Masonite Corporation. The purpose of this FS is to identify and evaluate alternatives that will facilitate remediation of the Bell Landfill site in Terry Township, Bradford County, Pennsylvania. This FS is based on the data and interpretations of the site discussed and presented in the 30 July 1993 Final Remedial Investigation Report (RI) prepared by ERM, Inc. and the 8 February 1994 Risk Assessment (RA) prepared by CDM Federal Programs for USEPA Region III. The FS provides sufficient data to select a remedial alternative for the site that will be protective of human health and the environment, meet ARARs, and properly balance the remaining remedy selection criteria.

The evaluation of remedial alternatives is intended to lead to a remedial action alternative that will be in accordance with CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR 300). Section 121 of CERCLA requires that remedial actions achieve a level of cleanup of hazardous substances that 1) protects human health and the environment, and 2) meets legally applicable standards promulgated by USEPA or a state for any hazardous substance or pollutants remaining on the site. In addition, the remedial action should be consistent with cleanup criteria and requirements that are "relevant and appropriate under the circumstances of the release or threatened release of such hazardous substance or pollutant or contaminant" (CERCLA, Section 121).

Of particular relevance to municipal landfill sites is the expectation listed in the NCP (40 CFR 300.430(a)(1)(iii)(B)) that engineering controls such as containment will be used for wastes that pose a relatively low long-term threat or for sites where treatment is impracticable. The preamble to the NCP identifies municipal landfills as a type of site where treatment may be impracticable due to the size and heterogeneity of the contents of many landfills. EPA has recognized the special nature of municipal landfills by issuing the February 1991 USEPA guidance document "Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites" (EPA/540/P-91/001) (Municipal Landfill Guidance). ERM has reviewed the information available on the site, including the site history, past disposal practices, and analytical data from site sampling activities. This information clearly indicates that the site is similar to municipal landfills with respect to construction, waste characterization, and leachate constituents and concentrations.

The format of this FS follows the guidelines outlined in USEPA's October 1988 interim final report "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (RI/FS Guidance), as modified by the Municipal Landfill Guidance. The 1991 guidance presents a streamlined version of the original FS format based on the limited number of practical remedial alternatives available for a typical municipal landfill site. The streamlined FS is divided into the following two phases:

- PHASE I - DEVELOPMENT OF REMEDIAL ALTERNATIVES
  - Identification of appropriate remedial action objectives;
  - Development of general response actions for each remedial action objective;
  - Determination of feasible, practicable technologies associated with each general response action; and
  - Assembly of technologies into remedial action alternatives.
- PHASE II - DETAILED ANALYSIS OF ALTERNATIVES
  - Definition of each remedial alternative with respect to the volumes of materials to be addressed, the technologies to be used, and any performance requirements associated with those technologies; and
  - Evaluation and comparison of alternatives using the following nine evaluation criteria:
    - Overall protection of human health and the environment;
    - Compliance with Applicable or Relevant and Appropriate Requirements (ARARs);
    - Long-term effectiveness and permanence;
    - Reduction of toxicity, mobility, or volume through treatment;
    - Short-term effectiveness;
    - Implementability;
    - Cost;
    - State acceptance; and
    - Community acceptance.

Because only practicable technologies are considered during technology selection, this focused approach eliminates the need to screen each technology and preliminary alternative on the basis of effectiveness, implementability, and relative cost.

In this report, Section 1 provides background information including the site description and history and the RI and RA results. Phases I and II of the FS process are presented in Sections 2 and 3, and Section 4 provides the summary and conclusions.

1.2 SITE BACKGROUND INFORMATION

1.2.1 Site Description

The former Bell Landfill is located in Terry Township, nine miles southeast of the town of Towanda in rural southeastern Bradford County, Pennsylvania (Figure 1-1). The site is accessible via Parker Road, an unimproved township road between the villages of New Era and Evergreen.

Regionally, the site is situated in a broad valley framed by prominent wooded ridges to the north and south. The valley is dissected by dendritic stream drainages, producing a hilly topography that supports dairy and related agricultural operations. The majority of the site is situated on the southern flank of a low hill with an approximate average elevation of 1,350 feet Mean Sea Level (ft MSL). Topographic relief between the site and the adjacent stream tributaries is approximately 100 feet. The region is sparsely populated with approximately 99 residents living within one mile of the site (NUS, 1986).

The land surrounding the site is primarily farm fields with wooded areas to the south and west of the site. The northern boundary of the site borders upon an open cornfield. The southern boundary abuts Parker Road, which provides access to the site. The eastern and western boundaries are parallel to, but set back from, two vegetated tributaries to Sugar Run. The western tributary appears to be an intermittent stream while the eastern tributary appears to be a perennial stream that originates from a small lake located 2,000 feet northeast of the site. The eastern tributary is also fed by an intermittent discharge from a shallow farm pond located 200 feet east of the site. The pond is situated at the head of a marshy lowland swale that borders the eastern boundary of the site.

The site has an areal extent of 33 acres and is rectangular in shape with its long axis oriented north-south. A six-foot high woven chain link fence surrounds the site, restricting the entry of animals and humans. This

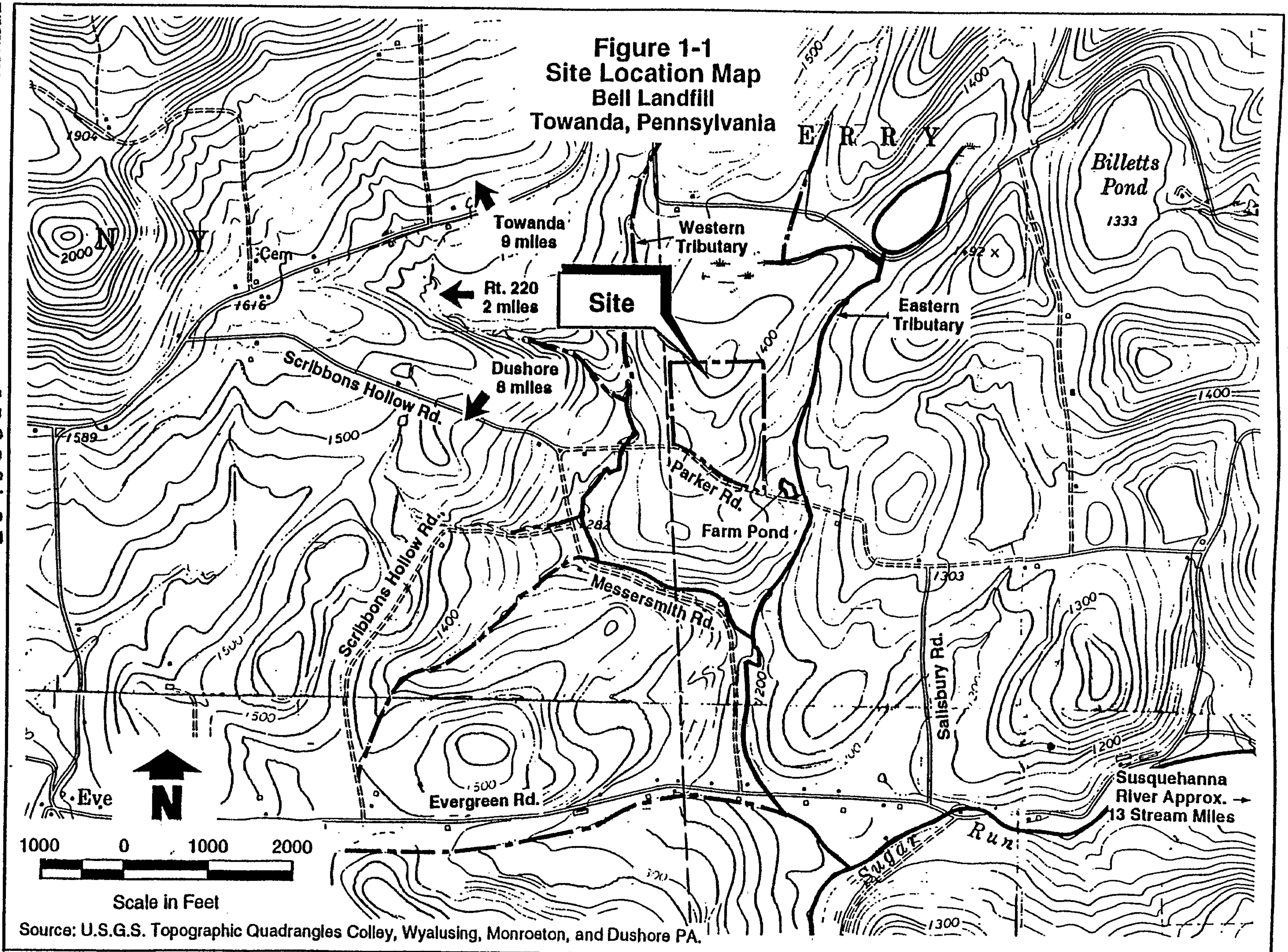


Figure 1-1
Site Location Map
Bell Landfill
Towanda, Pennsylvania

Source: U.S.G.S. Topographic Quadrangles Colley, Wyalusing, Monroeton, and Dushore PA.

fence was constructed by the SCs in June 1992, prior to the initiation of field investigation activities. While most of the 33-acre site is covered by mature conifers and other vegetation, a total of approximately five acres was developed into two separate municipal waste disposal (fill) areas (Plate 1). Other features of interest at the site include two soil borrow areas, the debris and drum disposal areas, and a pre-existing monitoring well installed by the site's former owner.

1.2.1.1 *Debris Area*

The debris area was the first area of the site to be used for waste disposal. Disposal activities reportedly began in this area in 1967 when Terry Township leased the land for a township landfill (personal communication, 1991). The landfill, which was in operation from approximately 1967 to 1969, was shut down when the township was unable to upgrade the operation to meet PADER requirements.

The debris area is located immediately east of the toe of the unlined fill area, along the crest of the slope which forms the marshy lowland swale east of the site (Plate 1). The debris consists of appliances (white goods), wood, plastic sheeting, crushed drum hulks and auto parts that were deposited along the crest of the hill and bulldozed over the side with minimal soil cover.

1.2.1.2 *Unlined Fill Area*

The unlined fill area was the second area at the site to be used for waste disposal activities. Aerial photo analysis indicates that landfilling in this area began prior to October 1969, with the activity in this area between 1969 and 1972 believed to be related to Terry Township landfilling operations. Full development of the unlined fill area occurred after Herbert Bell acquired the property in the early 1970s (Plate 1). Mr. Bell reportedly operated the unlined fill area from 1972 to 1978, but the landfill was never permitted by the Pennsylvania Department of Environmental Resources (PADER).

The unlined fill area comprises an area of approximately 2.93 acres and contains an estimated 59,600 cubic yards of waste material (ERM, 1993). The fill area is capped with native soil and supports a well established vegetative cover of tall grasses, small shrubs and trees. The thickness of the cap is not known, but waste materials are visible in some areas, suggesting that the cap was poorly installed.

Two main leachate seeps and associated reddish-brown stained soil and stressed vegetation are evident along the eastern toe of this fill area. A leachate perimeter drain along the eastern side of this fill area collects and conveys leachate to an underground 8,000-gallon steel tank located along Parker Road. The collected leachate overflows the tank and an area of stained soil and stressed vegetation is evident downslope of the tank.

1.2.1.3 *Lined Fill Area*

The lined fill area was constructed following the closure of the unlined fill area. The lined fill area was permitted by PADER and was constructed with an asphalt liner, leachate collection drain and tank, and leak detection drain (Plate 1). Municipal waste, as well as non-hazardous, industrial, residual waste, was disposed of in this area. The lined fill area was closed in 1982 and was capped with native soil that supports a well established cover of tall grasses, small shrubs, and trees. Although the thickness of the cap is not known, no waste materials are visible in this area. The estimated areal extent of this area is 2.54 acres and the volume of waste is approximately 56,900 cubic yards (ERM, 1993).

One large leachate seep and an area of stained soil and stressed vegetation are present half-way up the west slope of the fill area. The leachate collection drain conveys leachate to an underground leachate collection tank located 150 feet north of Parker Road at the southwest corner of the site. The capacity of this tank has been reported to be approximately 15,000 gallons (NUS, 1986). The collected leachate overflows the tank and an area of stained soil and stressed vegetation is evident downslope from the tank. A leak detection drain located beneath the asphalt liner discharges to a small on-site pond (herein referred to as the monitoring pond) located near the southern toe of the lined fill area.

1.2.1.4 *Drum Area*

In addition to the two fill areas and the debris area, there is one other notable disposal area on site. This area is referred to as the drum area. Located northwest of the unlined fill area, the drum area contains the crushed and rusted hulks of approximately 60 empty drums (Plate 1). Because of their condition, little or no markings are visible.

1.2.1.5 *Soil Borrow Areas*

Two areas of disturbed earth that are believed to represent former soil borrow areas are present on site (Plate 1). The first area is located near the northeast corner of the site. It appears to have resulted from the removal of approximately three feet of soil and currently exhibits a thin, rocky, soil cover with marginal vegetation.

The second borrow area is located adjacent to the north flank of the lined fill area and appears to have resulted from the removal of several feet of soil and rock cover. The area is currently rock covered with only minimal vegetation. A small area of ponded water and wetland-type vegetation is located north of this borrow area. Its genesis appears to be related to soil borrow activities as numerous bulldozer tracks are evident.

1.2.1.6 *On-site Wells*

One monitoring well was installed at the site prior to implementation of the RI. This 200-foot deep well, which is located near the northern boundary of the site, was installed by Herbert Bell, the landfill site's former owner.

1.2.2 *Site Conditions*

This section presents a general description of the geology at the site. Specific geologic and hydrogeologic findings are discussed in more detail in the Final Remedial Investigation, which is summarized in Section 1.2.3.4.

1.2.2.1 *Geology and Soils*

The site is located in the Appalachian Plateau Physiographic Province of north-central Pennsylvania. This plateau is characterized by a gently undulating surface underlain by a series of alternating anticlines and synclines. The structural dip of these features is shallow, generally less than 10 degrees. The site is situated on the southern, northward dipping limb of the Barclay Syncline. The axis of the syncline, located two miles north of the site, trends in an east-west direction and plunges gently to the west (PGS, 1939).

The bedrock which underlies the site and surrounding area is the Catskill Formation of upper Devonian Age. The formation varies in thickness from 1,200 to 2,000 feet (PGS, 1983). The site itself is underlain by alternating, nearly horizontal beds of very fine to fine-grained sandstone, siltstone, and shale. The east side of the site is underlain predominantly by the finer grained siltstones and shales compared to the west side of the site which is underlain by sandstone. This is consistent with the deltaic depositional characteristics associated with the Catskill Formation, in which significant changes in lithology (facies changes) are observed over relatively short lateral distances.

Bedding is reported to be well developed in most places, ranging in thickness from less than one foot to 10 to 16 feet in coarser beds. Crossbedding and other sedimentary features are also common (PGS, 1982). Site-specific strike and dip measurements were collected from a siltstone outcrop on the east side of the site. The outcrop is comprised of thinly-laminated, poorly bedded siltstone underlain by hackly, red-brown mudstone. The average strike of the bedrock is north 13 degrees east with the dip 3 degrees west.

Based upon caliper log responses, most of the monitoring wells at the site penetrate bedrock that is relatively unfractured. This apparent lack of water-bearing fractures was also evident during drilling when very low-yielding water bearing zones were encountered in each well. The two wells on the west side of the site exhibited the most fracturing. The presence of this fracturing, however, does not appear to enhance the hydraulic conductivity of the formation or contaminant migration. The wells on the east side showed little evidence of fracturing. The occurrence of fractures on the west side of the site may be due to the predominant sandstone lithology, as fracture density tends to be greater in sandstones than in shales and siltstones.

A regional soils map of the site is shown on Figure 1-2. Of the six soil series present on site, the Morris and Opuaga series are the most prevalent and underlie the unlined and lined fill areas. The Morris series soils contain a fragipan and are somewhat poorly drained. They exhibit a high seasonal water table and low to very low permeability. As indicated by Figure 1-2, these soils are found mainly under the lined fill area.

The Opuaga series soils do not contain a fragipan and are characterized as well drained to excessively well drained with moderate permeability. Bedrock is present at a moderate depth. These soils are mapped as occurring mainly under the unlined fill area.

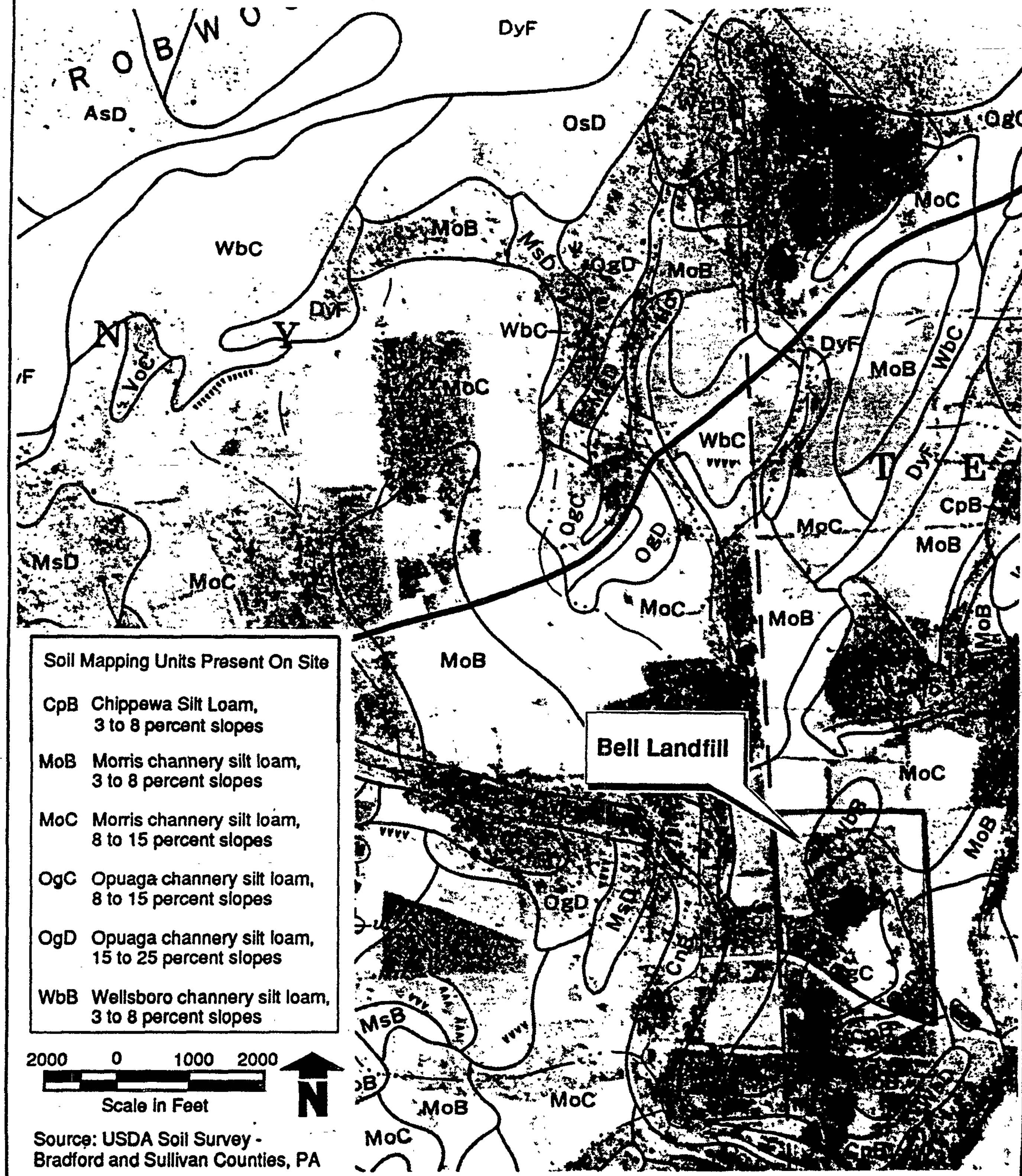
The Chippewa and Wellsboro soil units occupy a small portion of the site and lie outside of the unlined and lined fill areas. They are characterized by a fragipan, poor to very poor drainage, and a seasonally high water table.

Because of past earthmoving activities related to landfill construction and capping, the soils described above have been disturbed. Bedrock, coarse rock fragments, and vegetation are also present in areas used as soil borrow areas.

1.2.2.2 *Hydrogeology*

The site and surrounding area are situated in the glaciated region of Pennsylvania, although no glacial deposits are apparent on site. The majority of the wells in the area tap the Catskill Formation (NUS, 1986). Ground water in the Catskill Formation occurs in fractures and joints in the bedrock which create a secondary porosity of moderate magnitude

Figure 1-2
Regional Soils Map
Bell Landfill
Towanda, Pennsylvania



Source: USDA Soil Survey - Bradford and Sullivan Counties, PA

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(PGS, 1982). The bedrock has little primary porosity due to the fine-grained, well-indurated nature of the rock units.

Ground water flow beneath the majority of the site is generally from northwest to southeast, although a ground water divide is present across the northwestern portion of the site. Ground water flow on the northwestern portion of the site is to the west-southwest with a ground water discharge point at the western tributary. Ground water discharge from the rest of the site is to the eastern tributary, as indicated on the potentiometric surface map (Figure 1-3) and as demonstrated by the presence of a swampy swale area immediately east of the site.

Essentially all source areas are located south of the ground water divide. Vertical leachate migration from the unlined landfill enters the ground water system and discharges to the southeast. Using data collected during the RI, the estimated ground water flux beneath the unlined landfill is one gallon per minute. Although this number will vary based upon fracture frequency, it is consistent within an order of magnitude with the yield obtained from the on-site wells. A small portion of the lined landfill is located on the north side of the ground water divide. Insufficient data is available to estimate the flux beneath this fill area. However, the RI has shown that the liner appears to be fairly intact with most leachate collected by the collection system and leachate monitoring drain. Flux calculations are include in Appendix A.

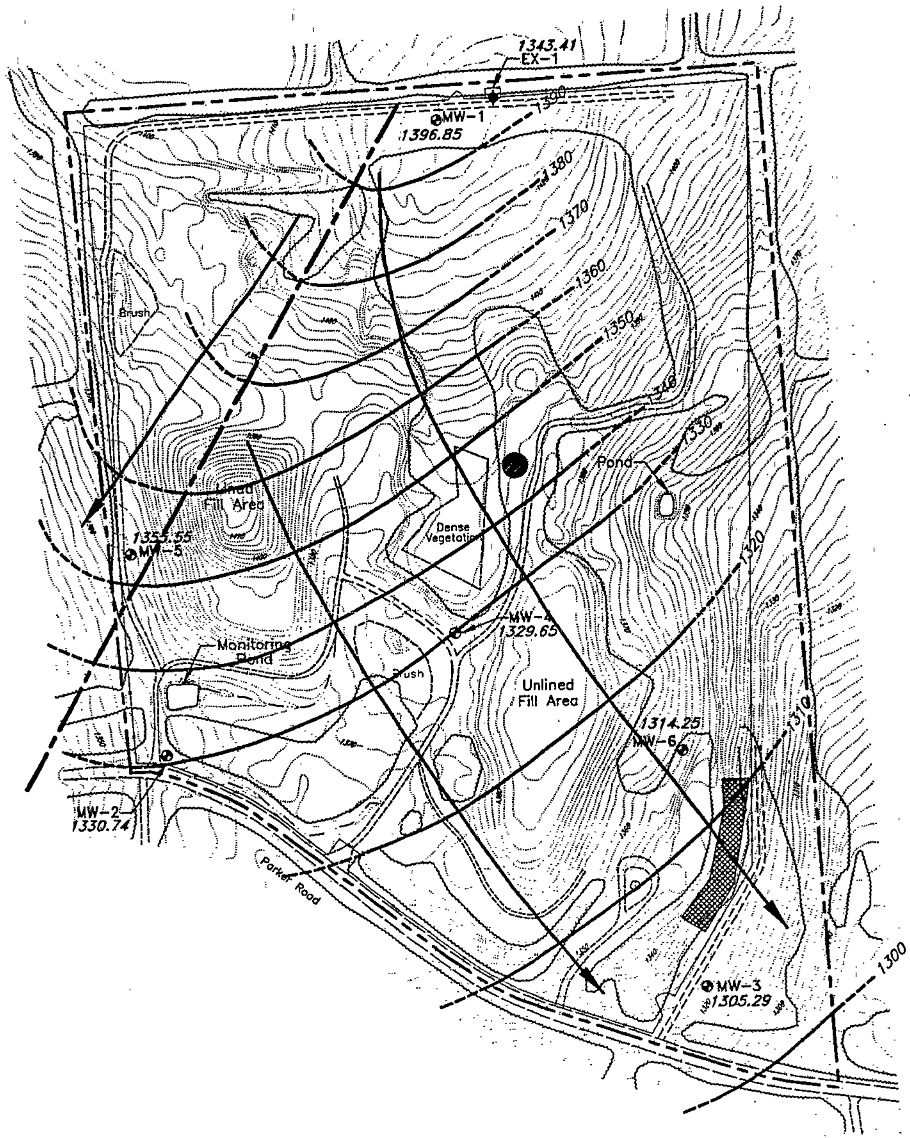
Site bedrock exhibits low hydraulic conductivity and shows little evidence of borehole fractures. The calculated hydraulic conductivities for the six on-site monitoring wells range from 0.0023 ft/day to 0.1495 ft/day. The low hydraulic conductivities of the monitoring wells indicate that the formation at these locations is not well fractured or that the fractures that are present are poorly conductive.

A steep ground water gradient (0.091) is evident in the northern portion of the site, while a flatter gradient (0.034) is found in the southern portion of the site. The average hydraulic gradient across the site is 0.063. Ground water flow along bedding is indicated by the flatter gradient on the south as well as a potential strike-related ground water discharge point in the western tributary. The site's topographic high position serves as a recharge area with a vertically-downward hydraulic gradient of 0.431 calculated in one location.

1.2.2.3 *Surface Water*

As discussed earlier, two unnamed tributaries to Sugar Run Creek are present along the eastern and western boundaries of the site. The eastern tributary is a second order perennial stream that drains a wetland area

Figure 1-3
Potentiometric Surface Map
Bell Landfill
Towanda, Pennsylvania



Legend

— — —	Property Line
=======	Dirt Access Road
—x——x—	Fence Line (Approximate)
EX-1 ◆	Existing Monitoring Well
MW-3 ⊘	Monitoring Well (Installed 1992)
	Approximate Extent of Debris Area
	Approximate Extent of Drum Area
1330.74	Elevation of Potentiometric Surface (Feet MSL)
—1340— —	Equipotential Line (Dashed Where Inferred)
→	Direction of Ground Water Flow
— — —	Potential Ground Water Divide

N

200 100 0 200

Scale in Feet

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located approximately 1,000 feet north of the site and an unnamed pond or small lake located 2,000 feet northeast of the site. The western tributary, located in a small, narrow, wooded hollow, drains the foothills of Robwood Mountain northwest of the site. Two intermittent, first-order streams merge approximately 600 feet north of Parker Road to form the western tributary.

Surface water runoff on the site generally flows to the southeast and southwest from a center divide located between the two fill areas. Runoff around the lined fill area is to the west and south, and runoff around the unlined fill area is to the east and south (Plate 1).

The eastern and western tributaries merge approximately 1,700 feet south of the site and then flow into Sugar Run approximately one mile south of the site. Sugar Run Creek, in turn, empties into the Susquehanna River approximately 13 miles east of the site. The tributaries and Sugar Run Creek are indicated on Figure 1-1.

1.2.3 *Chronology of Field Investigations*

Several investigations have been conducted at the site and surrounding area over the past ten years. Pertinent findings of these investigations are summarized in the following sections.

1.2.3.1 *1984 Investigations Conducted by NUS*

On 6 December 1984, NUS conducted a site inspection for EPA, during which several samples were collected and analyzed for volatile and semivolatile organic compounds. The sampled media included surface water and sediment from two leachate seeps, ground water, and surface water and sediment from the tributaries of Sugar Run Creek. The analytical results obtained are summarized below.

Total volatile organic compound (VOC) concentrations of 11,810 μg/l and 5,930 μg/l were reported from leachate seeps in the lined and unlined fill areas, respectively. The predominant compounds in both leachate samples were methylene chloride, acetone, and 2-butanone (all reported at levels of up to 2,700 μg/l). In addition, total xylenes were detected in leachate from the lined fill area at a concentration of 2,300 μg/l.

The sediment samples collected from the leachate seeps also contained the VOCs detected in the aqueous leachate samples. In addition to the VOCs listed above, the chlorinated organics trichloroethene and tetrachloroethene were also reported. Total VOC concentrations detected in sediment samples were 37,908 μg/l from the lined fill area and 5,700 μg/l from the unlined fill area.

Semivolatile organic compounds (SVOCs) were not detected at significant levels in the leachate samples. Total phenols were found in leachate samples from the unlined and lined fill areas at concentrations of 110 µg/l and 3,930 µg/l, respectively. Pentachlorophenol was detected in three of the four residential wells sampled but was not detected in the leachate samples.

Total VOCs were found in the on-site monitoring well at a concentration of 414 µg/l. Methylene chloride, acetone, and 2-butanone were each found at concentrations of up to 270 µg/l (ten times lower than the levels detected in the leachate samples). VOCs were not detected in the samples collected from the residential wells. No toxic metals were detected in samples collected from the residential wells or the on-site monitoring well.

No VOCs or SVOCs were detected in surface water samples collected from the tributaries of Sugar Run Creek along the eastern and western boundaries of the site. However, sediment samples collected from the tributaries contained acetone and bis (2-ethylhexyl) phthalate at concentrations of 40 µg/l and 390 µg/l, respectively.

1.2.3.2 *1985 and 1989 Investigations Conducted by PADER*

Because leachate had been observed discharging from seeps in the fill areas at the site, PADER in March 1985 conducted an aquatic survey on the two tributaries that drain the site. The objective of this study was to determine if the streams had been impacted by the leachate discharges. Five stream survey stations were established on the tributaries and one station was established in the farm pond (pond on Master's property).

Leachate discharges from the lined fill area were not found to have an impact on the water quality or aquatic life of the receiving stream (the western tributary of Sugar Run). Leachate discharges from the unlined fill area to the eastern tributary of Sugar Run did not seem to have an impact on the stream water quality. However, moderate degradation of the resident aquatic community was observed a short distance downstream of the discharge to the stream.

Samples collected from the farm pond indicated that leachate discharges to the pond were exerting an oxygen demand creating near oxygen-deficient conditions. The bluegills collected from the pond were stunted from overpopulation. The other fish species were found to be healthy with no tumors or lesions.

In March 1989, PADER sampled residential wells from the four residences located within one-half mile of the site to determine if there were any site-related impacts on ground water. Analysis of the collected samples did not indicate Target Compound List (TCL) contaminants above drinking water standards. Some samples from the wells did contain relatively high concentrations of iron and manganese, but the observed levels of manganese were attributed to the natural ground water-quality in this region of Pennsylvania and were not considered an indicator of pollution. High levels of iron were attributed to natural rusting of well casings or naturally occurring levels of iron.

1.2.3.3 *1991 Preliminary Investigations Conducted by ERM*

In May 1991, as part of the Work Plan preparation, ERM collected samples from the leachate collection tanks and seep locations at each fill area. Specific conductance and pH measurements were also taken at several locations in the eastern and western tributaries of Sugar Run, and a stream walk through was conducted by an ERM biologist.

Conductivity measurements on leachate discharges from the lined and unlined fill areas showed that the leachate from both areas has a specific conductance typical of municipal leachate. The conductivity of leachate from the lined fill area was 2 to 3 times higher than that from the unlined fill area.

Conductivity measurements in the two tributaries were several orders of magnitude lower than in the leachate, both upstream and downstream of the point of leachate discharge to each stream. These measurements indicated an absence of off-site impacts to the streams. A preliminary survey of macroinvertebrate populations, consisting of a stream walk through with casual observations of benthic life populations, also indicated a lack of site-related impact in either tributary.

Leachate from the two fill areas did not contain any pesticide or PCB compounds. Total VOCs at concentrations of 8,000 μg/l and 7,600 μg/l were detected in samples collected from the lined fill area leachate collection tank and leachate seep, respectively. Samples collected from the unlined fill area leachate collection tank and leachate seep contained total VOCs at concentrations of 3,900 μg/l and 3,300 μg/l, respectively.

Phenol and bis (2-ethylhexyl) phthalate were the only SVOCs detected. The concentrations of these compounds ranged from 30 μg/l to 1,100 μg/l in the unlined fill area and 20 μg/l to 4,100 μg/l in the lined fill area. Pentachlorophenol was not detected in samples from either area.

1.2.3.4 *1993 Remedial Investigation (RI) Conducted by ERM*

This section presents a summary of the Final Remedial Investigation Report submitted by ERM to EPA Region III on 30 July 1993.

RI field activities were undertaken by ERM in the fall of 1992. The field investigation tasks that were implemented are summarized below:

- performance of an electromagnetic conductivity (EM) survey to define the lateral extent of both the unlined and the lined fill area;
- collection of leachate samples from the leachate seeps and leachate collection tanks associated with both fill areas;
- collection of surface soil samples from the leachate seeps and the leachate collection tank overflows associated with both fill areas;
- collection of surface soil samples from the on-site drums areas and debris area;
- performance of a landfill gas migration study;
- installation of six bedrock monitoring wells to evaluate ground water quality, site geology, and aquifer parameters;
- sampling of the six newly-installed monitoring wells to evaluate ground water quality;
- sampling of five nearby residential wells to evaluate potential site-related impacts to the wells;
- performance of slug tests in the newly-installed monitoring wells to evaluate the hydraulic conductivity of the aquifer at the well locations; and
- performance of a chemical and biotic survey of the adjacent stream tributaries and farm pond to evaluate potential site-related impacts.

The results of the RI field investigation are summarized in the following subsections.

Unlined Fill Area

- The unlined fill area comprises an area of approximately 2.93 acres and contains an estimated 59,600 cubic yards of refuse. The cap is constructed of native soils and appears to be thin and poorly installed. Several leachate seeps are present along the southeastern side of the fill at the bedrock/soil interface. The average annual leachate generation rate for the unlined fill area is estimated at 3.0 gpm.
- Total volatile organic compound (VOC) concentrations in leachate ranged up to 9,300 μg/l and were comprised primarily of several ketones (acetone and MEK) and toluene. Lesser concentrations (up to several hundred μg/l) of chlorinated aliphatics and other aromatic hydrocarbons were also detected.

- Total semivolatile organic compound (SVOC) concentrations in the leachate ranged up to 2,666 µg/ and were comprised mostly of phenolic compounds. Diethylphthalate and two pesticides were also detected, but at low concentrations.
- From an inorganic quality standpoint, the leachate generated by the fill area is consistent with that of municipal waste. Nearly all of the heavy metals were present at concentrations below Primary Drinking Water Standards. Only barium and nickel marginally exceeded these standards. Primary Drinking Water Standards are not directly applicable to leachate and are used here only as a relative comparison. Common ions and miscellaneous wet chemistry parameters including iron, manganese, BOD, COD and ammonia-nitrogen were present at elevated concentrations.
- The concentration of total VOCs in leachate-stained soil ranged up to 171 µg/kg and were comprised primarily of toluene, ethylbenzene, xylene and acetone.
- Total SVOCs in the surface soil ranged from none detected to 1,000 µg/kg. Two phenolic compounds and naphthalene were the primary SVOCs detected. Low concentrations of delta-BHC, dieldrin, and PCB 1242 were also detected.
- Concentrations of TAL heavy metals in soil were generally consistent with, but somewhat elevated above, background concentrations. Cadmium concentrations were an order of magnitude above background. The common ions associated with leachate, iron and manganese, were also elevated above background.
- Total VOC concentrations were measured in soil gas to determine the potential for landfill gas migration. Although readings of greater than 1,000 ppm were detected up to 50 feet from the fill area in isolated areas, the potential for landfill gas accumulation and ignition is extremely unlikely given the undeveloped rural nature of the site and surrounding area.

Lined Fill Area Summary

- The lined fill area was used for the disposal of municipal waste as well as non-hazardous industrial (residual) waste. It comprises an area of 2.54 acres and contains an estimated 56,900 cubic yards of refuse. The liner beneath the fill area is constructed of an asphalt stabilized base with a leachate collection drain and monitoring drain located beneath the liner. The average annual leachate generation rate for the lined fill area is estimated at 2.6 gpm.
- Total VOC, SVOC, and pesticide concentrations in the monitoring drain discharge were similar to those in leachate from the leachate

collection tank. Ground water quality data, however, indicate the liner is fairly intact with no gross liner failure. Therefore, the water quality observed in the monitoring drain appears to be indicative of leachate leakage through the monitoring trench at the vertex of the liner. As-built drawings indicate this trench was not lined.

- The concentration of total VOCs in leachate from the collection tank was 66,906 μg/l, which was comprised mainly of methylene chloride, acetone, MEK, ethyl benzene, and xylene. Lesser concentrations of five VOCs totaling 2,200 μg/l were also present and included chlorinated aliphatic hydrocarbons, ketones, and aromatic hydrocarbons.

- The concentration of total SVOCs was 5,530 μg/l, which was comprised mostly of two phenolic compounds (5,400 μ/l total) and 130 μg/l of diethylphthalate.

- From an inorganic quality standpoint, the leachate generated by the fill area is consistent with that of municipal waste. Nearly all of the heavy metals were present at concentrations below Primary Drinking Water Standards. Only cadmium and nickel marginally exceeded these standards. Primary Drinking Water Standards are not directly applicable to leachate and are used here only as a relative comparison. Common ions and miscellaneous wet chemistry parameters including iron, manganese, BOD, COD and ammonia nitrogen were present at elevated concentrations.

- In general, all detected constituent concentrations were significantly higher in leachate from the lined fill area than in leachate from the unlined fill area. This difference has been attributed to the differences in age and degree of decomposition between the two fill areas.

- Total VOC concentrations in leachate-stained soils ranged up to 2,694 μg/kg and were comprised mostly of acetone, MEK, toluene, and xylene. Total SVOCs had a concentration of 213 μg/kg, which was comprised entirely of two phenolic compounds. Low concentrations of three pesticides were also detected. Most inorganic constituents were elevated above background.

- The monitoring pond sediment had a total VOC concentration of 480 μg/kg, comprised mostly of acetone, toluene, and xylene. Total SVOCs were 54 μg/kg comprised entirely of n-nitrosodiphenylamine. Delta-BHC was detected at an estimated concentration of 2.6 μg/kg.

- Total VOC concentrations were measured in soil gas to determine the potential for landfill gas migration. Although readings of greater than 1,000 ppm were detected adjacent to the toe of the fill area in isolated areas, the potential for landfill gas accumulation and ignition is extremely unlikely given the undeveloped rural nature of the site and surrounding area.

Drum Area Summary

- The drum area contains the crushed and rusted hulks of approximately 60 empty drums. No additional history or information is available concerning this disposal area. Low concentrations of 1,1,1-TCA were detected in surface soil samples collected from the drum area. SVOC concentrations in these samples were moderate and consisted of various PAHs. No pesticides or PCBs were detected in the soil; however, barium and lead concentrations were one and two orders of magnitude above background, respectively.

Debris Area Summary

- The debris area consists mainly of general debris (wood, auto parts, appliances, etc.) and an unknown number of empty, half-buried drums that appear to have been bulldozed over the side of a steep hill along with minimal soil cover. Very low levels of 1,1,1-TCA and 4,4-DDT were detected in surface soil samples collected within the debris area. No SVOCs or PCBs were detected in the debris area soil samples, and most inorganic parameters were within the concentration range found in the background soil sample, with the exception of cadmium, calcium, and manganese.

Ground Water Quality Summary

- Relatively low concentrations of only a few site-related constituents detected in the ground water at wells MW-4 and MW-5 and in the spring along the western portion of the lined fill area suggest that the asphalt liner may be fairly intact and functioning. However, leachate is likely being released from the leachate collection drain trench as evidenced by the near-continuous discharge from the monitoring drain and the quality of the discharge, which is similar to the leachate.

  In light of the water quality discussed above, a functioning liner, and the collection/monitoring drain serving as a wick-drain, the migration of leachate appears to be limited and is directed toward the monitoring pond rather than the ground water system.

  The lack of constituents in well MW-2 indicates that discharges from the lined fill area monitoring pond and leachate collection tank are not adversely affecting ground water quality.

- A limited number of site-related constituents are present in the ground water on the eastern border of the site, downgradient from the unlined fill area. These compounds are primarily chlorinated aliphatic and aromatic compounds. Total VOCs in the ground water range up to 75 µg/L in well MW-6. Natural biodegradation of ketones appears to be occurring in the vadose zone beneath this fill area, as evidenced by nondetections of ketones and low concentrations of chlorinated aliphatics in the ground water compared to elevated ketones and chlorinated aliphatic compounds in the leachate.

Residential Ground Water Quality

- No site-related constituents were detected in any of the residential wells. This is consistent with the results of residential well sampling conducted by PADER in 1989.

Stream Quality Summary

- Site-related constituents were generally not detected in the surface water or sediment of the adjacent tributaries, or if detected, were present at stream stations including the background station. The effects of leachate discharge to the east tributary, whether by direct surface runoff or ground water discharge, were not evident in the chemical sampling.
- With one exception, the occurrence of sensitive macroinvertebrate populations in the adjacent tributaries indicates that leachate discharges, whether by surface water runoff or ground water discharge, have resulted in no site-related impact on surface water. Station 6, however, on the eastern tributary downstream of the site and adjacent farm pond, exhibits a decrease in sensitive species and an increase in more tolerant species indicative of elevated water temperatures and/or dissolved oxygen stress. These impacts may be the result of unshaded stream conditions upstream of Station 6, eutrophic conditions in the farm pond that discharges upstream of Station 6, dissolved oxygen depletion from leachate discharges to the pond during wet weather, or seasonal influences from a site-related shallow ground water discharge.

The conclusions reached in the RI are summarized below.

- The wastes disposed on site were typical municipal wastes consisting of household and non-hazardous industrial refuse. There are no known or suspected "hot spots" of contamination in any area of the site.
- There is no impact to adjacent residential ground water users.
- Except for one location, there is no impact to adjacent surface water tributaries. Macroinvertebrate changes seen at this one location may be the result of the site and/or natural stream conditions.

- The adjacent farm pond receives leachate discharges from the site that contribute to the eutrophication of the pond.
- Both the lined and unlined fill areas as well as the existing leachate collection systems have been delineated. Leachate quality is typical of municipal waste.
- The rate of contaminant flux to the ground water is very small, based on the low levels of site-related contaminants present in ground water.
- The flow rate of ground water across the site is very slow, based on the observed hydraulic conductivities.
- Limited areas of leachate-stained soils are present on site and are consistent with the chemical quality of the leachate.
- The drum and debris areas are not significant source areas.
- The asphalt liner beneath the lined fill area is fairly intact. Leakage is occurring through the leachate collection trench, but its migration is limited.
- Impact to on-site ground water from the unlined fill area is limited to seven VOCs. Three of these VOCs are present at levels that are marginally above MCLs. However, there is no evidence of off-site migration of any of these VOCs. Natural biodegradation of ketones appears to be occurring in the vadose zone beneath the unlined fill area.

Based on the results of the RI, the following units have been identified as potentially requiring remediation:

- unlined fill area;
- lined fill area;
- leachate collection system;
- leachate-contaminated soils around the leachate collection tanks;
- drum and debris areas; and
- ground water.

1.2.4 *Site Risk Assessment*

The site risk assessment (RA) was conducted by CDM Federal Programs under contract to the USEPA. The procedures and results of the RA are summarized in the following paragraphs.

Data reported in the RI were used as the basis for the RA. Contaminants of Concern (COCs) were determined by comparing the medium-specific data to MCLs and/or risk-based concentrations developed by EPA. One or more COCs were identified for each of the following media: leachate, surface soil, ground water in monitoring and residential wells, surface water, and sediment.

Following identification of the COCs, current and future use exposure pathways and reasonable maximum exposure (RME) point concentrations for each COC were developed. The exposure routes evaluated included the following:

- inadvertent ingestion of leachate;
- dermal absorption of leachate;
- inadvertent ingestion of soil;
- inhalation of dust;
- ingestion of ground water;
- dermal absorption of ground water;
- inhalation of vapors evolved from ground water;
- inadvertent ingestion of surface water;
- dermal absorption of surface water;
- inadvertent ingestion of sediment; and
- dermal absorption of sediment.

The current use scenarios evaluated in the RA consisted of child trespassers and adult hunters entering the property and residents in the area who use private wells off site; future use scenarios consisted of child and adult residents and adult workers entering the property and/or using on-site ground water. The development of both the exposure scenarios and the RMEs were based on conservative assumptions, particularly regarding ingestion rate, contact rate, exposure time, and exposure frequency, likely resulting in an overestimation of risk. As stated in the RA, "The actual site risk may be lower than the estimates presented but is not likely to be greater."

The current and future use exposure scenarios were then integrated with the RMEs and EPA's reference toxicity values to determine quantitative estimates of risk. The toxicity values were developed by USEPA using reference dose values (RfDs) for noncarcinogenic effects and cancer slope factors (CSFs) for carcinogenic effects. The risks associated with the various media at the site are summarized below and in Tables 1-1 and 1-2.

Table 1-1
Summary of Cancer and Noncancer Risks by Exposure Route
Current Use Scenario
Bell Landfill Site

On-site Exposure	Exposure Route	Child Trespasser		Adult Hunter	
		Cancer	HI	Cancer	HI
	Inadvertent Ingestion of Leachate	5E-06	2.2	8E-06	1.2
	Dermal Absorption of Leachate	5E-06	0.3	2E-05	0.4
	Inadvertent Ingestion of Soil	6E-07	0.1	5E-07	0.02
	Inhalation of Dust	3E-09	1.00E-07	4E-09	1.00E-07
	Inadvertent Ingestion of Surface Water	NA	0.03	NA	0.02
	Dermal Absorption of Surface Water	NA	0.002	NA	0.002
	Inadvertent Ingestion of Sediment	NA	0.005	NA	0.001
	Dermal Absorption of Sediment	NA	0.001	NA	0.001
	Total Current Risk	1E-05	2.6	3E-05	1.6

Private Well	Exposure Route	Child Resident		24-yr Adult Resident		30-yr Adult Resident		Lifetime Resident (6-yr + 24-yr)	
		Cancer	HI	Cancer	HI	Cancer	HI	Cancer	HI
A	Ingestion of Groundwater	NA	0.4	NA	0.2	NA	0.2	NA	0.6
	Dermal Absorption of Groundwater	NA	0.001	NA	NA	NA	NA	NA	0.001
	Total Current Risk	NA	0.4	NA	0.2	NA	0.2	NA	0.6
C	Ingestion of Groundwater	1E-05	0.3	2E-05	0.1	3E-05	0.1	4E-05	0.4
	Dermal Absorption of Groundwater	6E-08	0.002	NA	NA	NA	NA	6E-08	0.002
	Total Current Risk	1E-05	0.3	2E-05	0.1	3E-05	0.1	4E-05	0.4
D	Ingestion of Groundwater	2E-05	0.6	4E-05	0.2	5E-05	0.2	6E-05	0.8
	Dermal Absorption of Groundwater	5E-08	0.001	NA	NA	NA	NA	5E-08	0.001
	Total Current Risk	2E-05	0.6	4E-05	0.2	5E-05	0.2	6E-05	0.8
F	Ingestion of Groundwater	NA	0.7	NA	0.3	NA	0.3	NA	1.0
	Dermal Absorption of Groundwater	NA	0.001	NA	NA	NA	NA	NA	0.001
	Total Current Risk	NA	0.7	NA	0.3	NA	0.3	NA	1.0

HI Hazard Index
NA Not Applicable

Table
Summary of Cancer and Noncancer Risks by Exposure Route
Future Use Scenario
Bell Landfill Site

Exposure Route	Child Resident		24-yr Adult Resident		30-yr Adult Resident		Lifetime Resident (6-yr + 24-yr)		Adult Worker	
	Cancer	HI	Cancer	HI	Cancer	HI	Cancer	HI	Cancer	HI
Inadvertent Ingestion of Leachate	3E-05	22.0	NA	NA	NA	NA	3E-05	22.0	NA	NA
Dermal Absorption of Leachate	1E-05	1.7	NA	NA	NA	NA	1E-05	1.7	NA	NA
Inadvertent Ingestion of Soil	2E-05	5.0	NA	NA	NA	NA	2E-05	5.0	4E-06	0.2
Inhalation of Dust	5E-08	0.000003	NA	NA	NA	NA	5E-08	0.0	3E-08	0.00000005
Ingestion of Groundwater	4E-04	36.9	7E-04	15.8	9E-04	15.8	1E-03	52.7	3E-04	5.6
Dermal Absorption of Groundwater	2E-06	0.1	NA	NA	NA	NA	2E-06	0.1	NA	NA
Inhalation of VOCs	NA	NA	3E-05	0.3	3E-05	0.3	3E-05	0.3	2E-05	0.2
Inadvertent Ingestion of Surface Water	NA	0.3	NA	NA	NA	NA	NA	0.3	NA	NA
Dermal Absorption of Surface Water	NA	0.01	NA	NA	NA	NA	NA	0.01	NA	NA
Inadvertent Ingestion of Sediment	NA	0.05	NA	NA	NA	NA	NA	0.05	NA	NA
Dermal Absorption of Sediment	NA	0.004	NA	NA	NA	NA	NA	0.004	NA	NA
Total Future Risk	5E-04	66.1	7E-04	16.1	9E-04	16.1	1E-03	82.2	4E-04	6.0

HI Hazard Index
NA Not Applicable
VOCs Volatile Organic Compounds

AR300504

- Under the current use scenarios, noncarcinogenic effects are possible as a result of exposure to manganese for a child trespasser and an adult hunter through ingestion of leachate and for a lifetime resident who uses water from the existing private well at residence F.
- A carcinogenic risk of $1x10^{-5}$ for a child trespasser is possible through ingestion and dermal absorption of leachate containing methylene chloride and vinyl chloride. A carcinogenic risk of $6x10^{-5}$ for lifetime exposure at one of the private residences (residence D) is possible primarily through ingestion of water containing arsenic. However, the EPA's acceptable target range for carcinogenic risk at Superfund sites is $1x10^{-4}$ to $1x10^{-6}$, such that the calculated carcinogenic risks for the current use scenarios are within the acceptable range. Furthermore, arsenic is present at background levels and its presence is not site related.
- Under the future use scenarios, noncarcinogenic effects are possible for child residents, adult residents, lifetime residents, and adult workers as a result of ingestion of ground water containing manganese. Carcinogenic risks of $4x10^{-4}$ for an adult worker to $1x10^{-3}$ for a lifetime resident are possible due to ingestion of ground water containing arsenic, although the arsenic is a naturally occurring constituent of ground water in the area and is not site related. The calculated carcinogenic risk levels are outside EPA's acceptable range.

2.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

2.1 OVERVIEW OF ALTERNATIVE DEVELOPMENT PHASE

As discussed earlier, the streamlined FS is a progressive screening process occurring in two phases:

- the development of remedial alternatives, and
- the detailed analysis of alternatives.

This section addresses the identification and screening of potentially feasible remedial technologies and the subsequent assembly of the screened technologies into remedial alternatives. The primary steps in this phase include the following:

- identification of appropriate site-specific remedial action objectives;
- development of general response actions to meet remedial action objectives;
- identification of feasible, practicable technologies associated with each general response action; and
- assembly of remaining technologies into remedial action alternatives.

2.2 IDENTIFICATION OF REMEDIAL ACTION OBJECTIVES

Remedial action objectives are site-specific environmental goals intended to facilitate the development of remedial alternatives that will be protective of human health and the environment. Remedial action objectives specify the constituents of concern, potential exposure routes and receptors, and acceptable constituent levels or ranges of levels for each potential exposure route. Public health and environmental concerns, along with ARARs (Applicable or Relevant and Appropriate Requirements), TBCs (material To Be Considered), and other cleanup criteria, form the basis for developing the remedial action objectives.

2.2.1 Development of ARARs

CERCLA, as amended by SARA, requires that remedial actions at Superfund sites comply with Federal or State environmental laws, standards, criteria, or limitations that are determined to be legally "Applicable" or "Relevant and Appropriate" requirements (ARAR). "Applicable" requirements are cleanup standards or other criteria promulgated under Federal or State law that specifically address a contaminant, action, location, or other situation at a site. "Relevant and Appropriate" requirements are cleanup standards or other criteria that, while not applicable to conditions at a site, address conditions sufficiently similar to those at the site that their use is well suited to the particular site.

Other non-promulgated policies, guidance, and directives may also be incorporated into the evaluation of remedial actions. These are termed "To-Be-Considered" (TBC) materials. Although they are not legally enforceable, TBCs may be used in conjunction with ARARs, or alone in situations where ARARs do not exist, to determine the appropriate level of cleanup for protection of health and the environment.

The selection of ARARs is dependent of the hazardous substances present at the site, the site's location and characteristics, and the actions selected for a remedy. Chemical-specific ARARs are health- or risk-based concentration limits set for a specific hazardous substance, pollutant, or contaminant. Location-specific ARARs address such circumstances as the presence of an endangered species on the site or the location of the site in a 100-year floodplain. Action-specific ARARs set controls on the design, implementation, and performance levels for remedial actions. US EPA has the responsibility for making the final determination of ARARs.

2.2.1.1 *Chemical-Specific ARARs/TBCs*

Soil, ground water, and leachate are the media of concern at the site. Chemical-specific ARARs/TBCs therefore consist of any Federal or State standards or criteria that address the contaminants detected in site soils, ground water, or leachate. There are currently no ARARs for soils or leachate as there are no promulgated standards for contaminants in these media under Federal or Pennsylvania law. However, the US EPA and the State of Pennsylvania have developed proposed/interim health-based action levels for soil that can be considered as TBCs (55 FR 30798, July 27, 1990; and Interim Cleanup Standards for Contaminated Soils, PADER, December 1993). ARARs for ground water include federal Maximum Contaminant Levels (MCLs) (40 CFR 141.11 - 141.16; 141.60 - 141.63), Maximum Contaminant Level Goals (MCLGs) (40 CFR 141.50 - 141.52), applicable provisions of the Pennsylvania Safe Drinking Water Act, and Pennsylvania's requirement, as described in the Pennsylvania Ground Water Protection Strategy, that contaminated ground water be restored to background conditions. Chemical-specific ARARs/TBCs for constituents detected in ground water at levels exceeding the applicable standard are summarized in Table 2-1. No constituents detected in soils exceeded either the federal or state proposed/interim soil cleanup levels.

Table 2-1
Chemical-Specific ARARs/TBCs for the Bell Landfill Site

Ground Water Constituent	Maximum Level Detected (Concentrations in µg/L)	ARAR/TBC (Source) (Concentrations in µg/L)
Vinyl chloride	5 (MW-3)	2 (MCL); ND (Background)
Trichloroethene	32 (MW-6)	5 (MCL); ND (Background)
Tetrachloroethene	8 (MW-6)	5 (MCL); ND (Background)
Arsenic	37.2 (MW-6)	50 (MCL); <5.5 (Background)
Cadmium	8.6 (MW-6)	5 (MCL); 3.6 (Background)
Iron	67,400 (MW-6)	300 (Secondary MCL); 30,800 (Background)
Manganese	2,010 (MW-6)	50 (Secondary MCL); 882 (Background)
Lead	76.1 (MW-5)	50 (MCL); 6.6 (Background)
Thallium	4.4 (MW-5)	2 (MCL); ND (Background)

2.2.1.2 *Location-Specific ARARs/TBCs*

The geographic location of a site can modify its effect upon human health and the environment. The Bell Landfill site is not located in a sensitive habitat, such as a floodplain, wildlife refuge, park, or recreational area, and the ecological assessment conducted during the RI determined that there are no endangered or threatened species living in or using the site. Although there are three small emergent wetlands located within the site, these areas are outside the units identified as potentially requiring remediation (Section 1.2.3.4) and will not be affected by remedial activities. Thus, no location-specific ARARs have been identified for the site.

2.2.1.3 *Action-Specific ARARs/TBCs*

Action-specific ARARs are technology- or activity-based requirements for remedial actions taken at a site. A number of potential action-specific ARARs have been identified for the Bell Landfill site.

Cap Construction

Capping the fill areas would require compliance with Pennsylvania regulations governing landfill closure, including cap design and construction requirements, site inspection and maintenance, and long-term monitoring (25 PA Code 271.113; 25 PA Code 273.234).

Air Emission Standards

Excavation and cap construction could be regulated by Federal and State air emission standards, including the Clean Air Act National Ambient Air Quality Standards and 25 PA Code Section 121.7, respectively. Control of particulates would likely be the only potential concern, although monitoring for organic emissions during excavation could be required to assure that no significant emissions were generated.

Off-Site Transportation and Disposal

Off-site transportation and disposal of any wastes will require compliance with Department of Transportation requirements.

Erosion Control

An erosion and sedimentation control plan may be required in order to implement earth moving and construction activities (25 PA Code 102).

Discharge to Surface Water

The discharge of treated ground water to a nearby stream would require compliance with the NPDES regulations, including limits on constituent concentrations, use of best available treatment technologies, and ongoing monitoring of the discharge and receiving water body (40 CFR 122; 40 CFR 125; 25 PA Code Sections 91, 92, and 93).

2.2.2 *Development of Remedial Action Objectives*

Based on the results of the site RA, the principal contaminant of concern at the site is manganese, which is present in ground water and leachate. Exposure to other contaminants of concern may occur through direct contact with or accidental ingestion of ground water and leachate at the site. Since soil contaminant levels do not present any excess risk under current exposure scenarios and do not exceed the TBCs, soil is not a direct medium of concern. However, since it may be impacted by continued contact with leachate and if not remediated may present a future risk, soil is retained as a unit that will be remediated. The remedial action objectives for the site, developed to protect human health and the environment, are listed below:

Soils

- Limit exposure of soils to other contaminated media, such as leachate and ground water, even though soil contaminant levels do not present an unacceptable risk to human health or the environment and there are no identified ARARs for this medium.

Ground Water

- Reduce exposure to or ingestion of site-related ground water so that exposure risk level is between 10^{-4} and 10^{-6} excess cancer risk and hazard index is less than 1;
- Mitigate contamination such that ARARs are met in the aquifer, if feasible;
- Control off-site migration of contaminants in ground water; and
- If ARARs or acceptable risk levels cannot be met, implement institutional controls such that no unacceptable risk to human health or the environment shall occur through use of contaminated ground water.

Leachate

- Mitigate surface discharge of leachate such that risk to human health or the environment is between 10^{-4} and 10^{-6} excess cancer risk and hazard index is less than 1;
- Mitigate leachate generation and transport to ground water to reduce continued impact to ground water.

2.3 GENERAL RESPONSE ACTIONS

The second step in Phase I is to determine appropriate general response actions. General response actions are measures which, by themselves or in combination with other general response actions, will satisfy the remedial action objectives. These response actions are broadly defined measures designed to prevent or minimize the impact of constituents that have migrated into environmental media.

As defined in Section 1.2.3.4, there are six units that potentially require remediation at the Bell Landfill site:

- unlined fill area;
- lined fill area;
- leachate collection system;
- leachate-contaminated soils around the leachate collection tanks;
- drum and debris areas; and
- ground water.

The remediation of the fill areas, leachate collection system, ground water, and leachate contaminated soils are interrelated. Furthermore, the drum and debris areas are very small and the characteristics of soils in those areas offer some efficiency for managing these areas in concert with the fill areas. Therefore, this evaluation considers the general response actions collectively for all media.

General response actions considered for remediation of the Bell Landfill site include the following:

- No Action:

  No remedial measures would be employed on the site. Long-term site monitoring could be required.

- Institutional actions:

  Site controls, such as fencing and deed restrictions, that restrict site access and limit future land use. Long-term site monitoring could be required.

- Containment:

  Application of cover or cap material to control airborne and leached constituents, isolate waste, and address seeps.

- Removal:

  Complete or partial excavation/removal of soils and/or waste materials for off-site or on-site treatment and/or disposal.

- Diversion/Collection of Surface Waters and Run-on/Run-off :

  Site-wide controls to minimize infiltration and erosion.

- Disposal:

  On-site or off-site disposal for soils and waste materials.

- Ground water collection/treatment/disposal:

  Collection of ground water for treatment or disposal.

- Leachate collection/treatment/disposal:

  Collection of leachate from leachate system for treatment or disposal.

2.4 *TECHNOLOGY SCREENING*

Based on the determination of appropriate general response actions and media of concern, practicable, feasible technologies that apply to each general response action are identified and screened. The screening of each technology considers all media at the site to which the technology might apply, e.g., a containment technology such as capping could potentially apply to ground water, solid wastes, and soils. Potential remedial technologies are identified based on previous experience with other sites and published literature on conventional and innovative alternative technologies. Only technologies considered applicable to the Bell Landfill site are included in this evaluation. The objective in this screening step is to eliminate those technologies that are not technically feasible at the site. Each of the potential technologies is described and briefly evaluated in the following subsections.

2.4.1 *No Action*

Description: No action means that no additional remedial actions would be conducted for any of the media of concern at the site. Maintenance of the existing caps and long-term ground water monitoring could be part of a No Action alternative.

Initial Screening: Although No Action does not met the remedial action objective for the site, it is retained as a baseline against which other alternatives will be compared.

2.4.2 *Institutional Actions*

Description: Institutional actions are a class of controls that can be used to eliminate the potential for exposure to the contaminated soil, leachate, and ground water at the site. These controls include the following:

- Perimeter fencing of selected areas to restrict access;
- Zoning restrictions for the site, limiting future land use;
- Deed restrictions for the site, limiting future land and ground water use;
- Ownership control: site could be deeded to a government entity; and
- Long-term monitoring.

The use of fencing and/or restrictions on land use would restrict human access and provide some protection for human health. Deed restrictions for future land use may be easily instituted but may prove difficult to enforce. Depending on the type of controls instituted, cooperation among various governmental agencies could be required. Regular inspections and monitoring of the site would be necessary to ensure continued implementation.

Initial Screening: This response action would not meet the remedial action objective for the site and is eliminated from further consideration as a stand-alone remedy. However, institutional controls will be retained for inclusion in the site-wide alternatives as a means to preserve the integrity and protectiveness of the selected remedy.

2.4.3 *Containment (Capping)*

Containment technologies reduce the potential for direct exposure to site contaminants and the potential for migration of contaminants by physically isolating the contaminated media or wastes. Capping is a containment technology that places a physical barrier over contaminated

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areas. Capping is commonly performed when waste volumes are large and the excavation and removal of the waste is precluded by potential hazards and/or unrealistic costs (EPA, 1991). Capping can be used to prevent direct contact with contaminated materials, to control emissions of gases and odors, and to restrict the infiltration of surface water and subsequent leachate generation. Three potentially applicable capping options have been identified, as discussed below. A more detailed discussion of various capping options and their estimated performance is presented in Appendix B.

2.4.3.1 *Soil Cover*

Description: A soil cover consists of a layer of clean soil fill, covered by a thin topsoil layer, placed over the areas of concern. The soil cover is graded to control surface water runoff and reduce infiltration and vegetated to reduce erosion. Construction of a soil cover would be relatively easy and inexpensive, utilizing standard construction techniques. Periodic maintenance would be required to maintain the integrity of the cover. Compared to other capping options, the effectiveness of a soil cover at reducing surface water infiltration is low. A soil cover would not satisfy the PADER closure requirements for municipal waste landfills.

Initial Screening: This technology does not significantly reduce surface water infiltration or potential leachate generation, nor does it satisfy PADER closure requirements. Therefore, this technology will be eliminated from further consideration.

2.4.3.2 *Single Barrier Cap*

Description: A single barrier cap is a cover system which includes one impermeable barrier layer in combination with various other layers (e.g., soil bedding, gas collection, drainage, protective cover and topsoil layers), as appropriate. An impermeable barrier layer generally refers to a layer of clay with a minimum thickness of 12 inches and a maximum hydraulic conductivity of $1x10^{-7}$ cm/sec or a synthetic flexible membrane liner (FML). Single barrier caps typically consist of, from bottom to top, a low-permeability barrier layer, a drainage and/or cover soil layer, and a vegetated topsoil layer. The typical PADER cap design for municipal waste landfills (PADER-type cap) is a type of single barrier cap and may include either a clay barrier layer or a synthetic membrane barrier layer. An example of an alternate single barrier cap is the ERM-Value Engineered (ERM-VE) cap, which uses a heavier synthetic membrane liner than is required for the typical PADER-type cap. The materials, equipment, and labor required to construct all of the caps mentioned herein are readily available. Periodic maintenance would be required to maintain the integrity of the cover layers. A single barrier cap is more expensive than a soil cover, but it is also much more effective at reducing surface water infiltration and leachate generation. Furthermore, an enhanced cap such as the ERM-VE cap provides essentially the same leachate reduction as is achieved by a composite barrier cap. A single barrier cap is one of the most common methods of waste containment.

Initial Screening: This technology is a proven and effective method of waste containment, and it meets or exceeds the potentially applicable closure requirements. Thus, this technology is retained for further consideration.

2.4.3.3 *Composite Barrier Cap*

Description: A composite barrier cap refers to a cap that includes two or more impermeable barrier layers in combination with various other layers (e.g., soil bedding, gas collection, drainage, protective cover and topsoil layers), as appropriate. A common composite barrier is the typical RCRA-type cap recommended by the EPA ("Final Covers on Hazardous Waste Landfills", EPA/530-SW-89-047). The typical RCRA-type cap typically includes the following layers, from bottom to top: a two-foot thick low-permeability clay liner, a 30-mil FML, a one-foot thick sand drainage layer, a two-foot thick cover soil layer, and a vegetated cover. This type of cover would exceed the PADER design requirements for municipal waste landfill caps. The materials, equipment, and labor required to construct this type of cap are readily available. Periodic maintenance would be required to maintain the integrity of the cover. This type of cap is usually much more expensive than a single barrier cap. Depending on its construction, a composite barrier cap may be essentially equivalent to, or somewhat more effective than, a single barrier cap at restricting infiltration.

Initial Screening: Due to its proven effectiveness and ability to exceed the PADER requirements, this technology will be retained for further consideration.

2.4.4 ***Removal***

Description: Removal would entail the physical removal or excavation of soil, debris, or other waste materials from the site. The removed materials could be transported to other areas of the site or taken off site for recycling or disposal. Removal is generally accomplished with conventional heavy construction equipment, such as backhoes, bulldozers, loaders, and cranes.

Conclusion: Removal is not practical as a stand-alone remedy because of the large volume of waste material and the relatively low long-term threat posed by the site, as summarized in Sections 1.2.3.4 and 1.2.4. However, it may be incorporated into the site-wide alternatives as a means to manage selected waste materials.

2.4.5 *Diversion/Collection of Surface Waters and Run-on/Run-off*

2.4.5.1 *Grading*

Description: Grading consists of changing or recreating a site's contours to enhance the performance of a remedial action. Grading is generally used to control site run-on and run-off and minimize infiltration into areas where wastes remain on site. Surface grading can serve several functions, including the reduction of run-off velocities (reducing soil erosion), as well as roughening and loosening soils (in preparation for revegetation).

Conclusion: Grading by itself is not an effective remedial option, but it is an essential component of any remedy that includes capping. This technology is therefore retained for inclusion as a component of the site-wide alternatives.

2.4.5.2 *Revegetation*

Description: The establishment of a vegetative cover through the mulching and seeding of exposed soil is a cost-effective method to stabilize the surface of waste disposal sites, especially when preceded by grading. Revegetation decreases erosion by wind and water, minimizes dust formation, promotes evapotranspiration, and contributes to the development of a naturally fertile and stable surface environment. Grass cover is commonly used for revegetation on capped areas, but other shallow-rooted plants may also be used. The use of indigenous plant species for revegetation is often preferred. Vegetation may also be used to form physical barriers and limit access to portions of a site.

Initial screening: Revegetation by itself is not an effective remedial option, but it is an essential component of any remedy that includes capping. This technology is therefore retained for inclusion as a component of the site-wide alternatives, with the condition that indigenous or native plants will be used when possible.

2.4.6 *Disposal*

Description: Disposal entails placing soils or other materials at off-site facilities or into the existing landfills at the site. Disposal could be used to aggregate similar types of waste into one area at the site or to provide final placement off site for recyclables and other debris.

Initial Screening: Off-site disposal is not practical as a stand-alone remedy for the landfill contents because of the large volume of waste materials. It is practical for the much smaller volumes of debris and leachate-contaminated soils. On-site disposal is feasible and practical for all solid materials at the site, but it is not acceptable as a stand alone remedy. However, it will be retained for inclusion into the site-wide alternatives, particularly as a component of capping.

2.4.7 *Ground Water Collection/Treatment/Disposal*

Description: Ground water collection requires the installation of wells, interceptor trenches, or some other type of collection system to create a cone or area of depression and induce water flow toward the collection point(s). Ground water recovery is most feasible under conditions of moderate to high hydraulic conductivity and least feasible in low-yielding, low conductivity formations. Active recovery of contaminated ground water can remove contaminant mass from an aquifer and potentially shorten the time frame for remediating the ground water to background conditions.

Collected ground water may be treated on or off site, with the treated water discharged to surface water or to a local POTW or recharged to the ground. Typical treatment technologies include air stripping, chemical oxidation, biodegradation, and activated carbon for organics removal and chemical precipitation and ion exchange for metals removal.

Initial Screening: Ground water collection and treatment is retained as a potential technology for ground water remediation. However, the feasibility of ground water recovery is questionable and will be discussed in detail in Section 3.2.3.2.

2.4.8 *Leachate Collection/Treatment/Disposal*

Description: Leachate collection would entail renovation of the existing leachate collection system at the site. The perimeter drain at the unlined landfill would be rebuilt, the existing leachate collection tanks at both fill areas would be replaced, and a new leachate storage tank would be installed and piped to the new collection tanks. The collected leachate would be pumped out as necessary and either treated on site or transported off site for appropriate treatment and disposal.

Initial Screening: Because leachate collection and treatment would meet the remedial action objective for leachate at the site, this technology is retained for inclusion in the site-wide alternatives.

2.5 *DEVELOPMENT OF REMEDIAL ALTERNATIVES*

In this section, the potential remedial technologies identified in Section 2.4 are grouped into site-wide remedial action alternatives. Site-wide alternatives are logical for this site because of the interrelationship between waste materials, leachate generation, and ground water quality. The proposed alternatives include the range of feasible, practicable technologies available for each unit of concern. Although not explicitly developed herein, additional alternatives, such as single barrier capping in conjunction with ground water recovery and treatment, are implicitly included in this FS. The remedial alternatives are listed below, named simplistically in terms of the principal technologies to be employed. These alternatives are evaluated in detail in Section 3 of this report.

Alternative 1:	No Action
Alternative 2:	Single Barrier Capping, Leachate Collection, and Ground Water Monitoring
Alternative 3:	Composite Barrier Capping, Leachate Collection, and Ground Water Collection and Treatment

3.0 DETAILED EVALUATION OF ALTERNATIVES

The purpose of the detailed evaluation is to present sufficient information on each of the alternatives to allow selection of the optimum site remedy. Nine specific evaluation criteria have been developed to address CERCLA requirements and the other technical and policy considerations that EPA has found to be important for selecting a site remedy:

- Overall protection of human health and the environment;
- Compliance with ARARs;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability;
- Cost;
- State acceptance; and
- Community acceptance.

The nine criteria have been categorized into three groups to reflect the revised emphasis of the 8 March 1990 revision to the NCP. Threshold criteria, which include overall protection of human health and the environment and compliance with ARARs, are requirements that must be met in order for an alternative to be eligible for selection. The primary balancing criteria, which include long-term effectiveness and permanence, reduction of toxicity, mobility, or volume through treatment, short-term effectiveness, implementability, and cost, are to be used to assess the tradeoffs among alternatives. Modifying criteria, which include state and community acceptance, are to be factored into the final evaluation of the tradeoffs among alternatives.

The Municipal Landfill Guidance incorporates the above-listed nine criteria, although there are some aspects of these criteria that may not apply to municipal landfills. The NCP identifies municipal landfills as a type of site where treatment may be impracticable due to the size and heterogeneity of the contents and the relatively low long-term threat posed to the environment, conditions that exist at the Bell Landfill site. As a result, the NCP expresses the expectation that containment is the most likely remedy. Other expectations for remediation in the NCP that apply to municipal landfills are summarized as follows:

- A combination of engineering controls and treatment will be used to achieve overall protection of human health and the environment and to mitigate hot spots, respectively;
- Institutional controls such as deed and access restrictions will be used in conjunction with engineering controls as appropriate to limit future site use and waste disturbance;
- Ground water will be returned to beneficial uses when practical, within a reasonable time, depending on the characteristics of the site; and
- Innovative technologies will be considered when they have the potential to provide superior treatment performance or lower costs with equivalent performance when compared to demonstrated technologies.

Consideration of these expectations has resulted in EPA's developing a streamlined approach to technology selection and a modified evaluation process for municipal landfills. This streamlined approach includes revised interpretations of the nine evaluation criteria to include only those criteria that are applicable to the site being evaluated. For example, reduction of toxicity, mobility, or volume through treatment is often not relevant, since treatment is typically not a practicable technology for municipal landfill remediation. The revised use of the evaluation criteria is discussed further in the next section. The Bell Landfill site will be evaluated against only those aspects of the criteria that are applicable to each potential remedy and the site.

3.1 ALTERNATIVE EVALUATION PROCEDURES

In order to perform the detailed evaluation of alternatives according to the requirements of CERCLA, a three-stage evaluation process was developed in the RI/FS Guidance. This process, consisting of alternative definition, detailed evaluation, and comparative analysis, is described in more detail in the following subsections.

3.1.1 Alternative Definition

Each alternative will be more fully defined in order to develop appropriate remedy specifications and the required order-of-magnitude cost estimates. This will include such things as refining the volumes of soil/waste to which specific actions would apply and describing how the remedial actions would be applied to the various units.

3.1.2 *Detailed Evaluation*

The detailed evaluation will be based on the interpretation of the nine criteria as presented in the Municipal Landfill Guidance. A description of each of these criteria is presented in the following subsections.

3.1.2.1 *Overall Protection of Human Health and the Environment*

The assessment against this criterion evaluates how each alternative achieves and maintains protection of human health and the environment, how site risks are reduced for the pathways being addressed, and how each source of contamination is to be eliminated, reduced, or controlled. The primary site risks to be addressed include direct contact with and ingestion of contaminated ground water and leachate.

3.1.2.2 *Compliance with ARARs*

Each alternative will be evaluated to determine how it complies with Federal and State ARARs. When an ARAR is not met, the basis for a waiver as allowed under CERCLA will be discussed. The primary ARARs for the Bell Landfill site, as presented in Section 2.2, are assumed to include the following:

- ARARs for ground water include federal Maximum Contaminant Levels (MCLs) (40 CFR 141.11 - 141.16; 141.60 - 141.63), Maximum Contaminant Level Goals (MCLGs) (40 CFR 141.50 - 141.52), applicable provisions of the Pennsylvania Safe Drinking Water Act, and Pennsylvania's requirement, as described in the Pennsylvania Ground Water Protection Strategy, that contaminated ground water be restored to background conditions.
- ARARs for capping the fill areas would require compliance with Pennsylvania regulations governing landfill closure, including cap design and construction requirements, site inspection and maintenance, and long-term monitoring as contained in 25 PA Code 271.113 and 25 PA Code 273.234.
- ARARs for air emissions include the Clean Air Act National Ambient Air Quality Standards and 25 PA Code Section 121.7.

3.1.2.3 *Long-term Effectiveness and Permanence*

This criterion requires an evaluation of the risk remaining at the site after response objectives have been met. Areas that should be addressed for each alternative include the magnitude of remaining risks (i.e., the volume, toxicity, and mobility of the residuals), the adequacy and suitability of controls used to manage treatment residuals or untreated wastes remaining on the site, and the long-term reliability of the management controls for providing protection from residuals.

3.1.2.4 *Reduction of Toxicity, Mobility, or Volume Through Treatment*

This criterion addresses the SARA preference for those remedial alternatives that permanently and significantly reduce the toxicity, mobility, or volume of the hazardous materials at a site through treatment. This criterion is not considered applicable to solid media at the site because there are no known hot spots in the landfill areas. The evaluation of remedial options for leachate and ground water will be conducted against this criterion.

3.1.2.5 *Short-term Effectiveness*

The evaluation of short-term effectiveness is based on the protectiveness of human health and the environment achieved during the construction and implementation phase of the remedial action. Factors to be considered in this evaluation include protection of the community, protection of workers, short-term environmental impacts, and the time until remedial response objectives are achieved.

Issues to be considered for the Bell Landfill site include the following:

- preventing excessive exposure to waste materials during construction;
- limiting the length of time required to construct the cap system and ground water and leachate collection and treatment systems; and
- preventing cross-media contamination or exacerbation of existing site conditions.

3.1.2.6 *Implementability*

The implementability of each alternative will be evaluated based on its technical and administrative feasibility and the availability of services and materials. Technical feasibility takes into consideration the difficulties that may be encountered during construction and operation, the reliability of the technologies, the ease of undertaking additional remedial action, and the ability to monitor the effectiveness of a remedy. Administrative feasibility encompasses the activities required to coordinate with other offices and agencies, such as obtaining permits for remedial activities. The availability of services and materials includes the ability to secure the necessary equipment, specialists, materials, and off-site treatment, storage, and disposal services.

Issues of importance at the Bell Landfill site are the feasibility of ground water recovery, the ability to apply cap systems that meet the remedial action objectives, and the feasibility of ground water and leachate treatment.

3.1.2.7 *Cost*

Evaluation of the cost of each alternative generally includes the calculation of capital costs, O&M costs, and the net present worth. Capital costs consist of the direct costs for items such as labor, materials, equipment, and services plus the indirect costs for engineering management, permits, startup, and contingencies. Operating and maintenance costs, or annual costs, are the post-construction costs necessary to maintain the remedial action. O&M costs include such items as operating labor, maintenance, auxiliary materials, and energy. The net present worth is based on both the capital and the O&M costs, and provides a means of comparing the cost of different alternatives. The costs are considered order-of-magnitude estimates and have an expected accuracy within +50 percent and -30 percent as defined by the American Association of Cost Engineers. This range of accuracy is also consistent with current USEPA guidance for FS reporting (USEPA, 1988). The present worth analysis is based on a 30-year period of operation and a 5% discount rate.

3.1.2.8 *State Acceptance*

State acceptance has been determined based upon PADER comments to the draft FS, to which responses to the comments have been incorporated in this document.

3.1.2.9 *Community Acceptance*

Community acceptance will be evaluated according to EPA and PADER requirements.

3.1.3 *Comparative Evaluation Among Alternatives*

After each alternative has been individually evaluated against the first eight of the nine criteria, comparisons among the alternatives will be made. The range of alternatives will be compared criterion by criterion to define the remedy that strikes the optimal balance among the selection criteria. This comparison will provide the information needed to select a remedy for the site.

3.2 INDIVIDUAL ALTERNATIVE EVALUATION

In this section, the three site-wide remedial alternatives are evaluated against eight of the nine selection criteria. Appendix C provides detailed design assumptions and cost estimates for each alternative.

3.2.1 *Alternative 1 - No Action*

3.2.1.1 *Alternative Description*

Under the No Action alternative, no further remedial measures would be undertaken at the site. The existing fence and landfill covers would be maintained, and long-term ground water monitoring would be instituted. There would be no repair to the leachate collection drain at the unlined landfill.

Rainfall would continue to infiltrate the surface cover on both landfills, and leachate would continue to be generated. Leachate seeps and overflow from the leachate collections tanks would be expected to continue for an indefinite period of time. Current ground water impacts would continue indefinitely. The existing risks associated with exposure to contaminants at the site would persist until such time as contaminant levels in the leachate, soils, and ground water were reduced through natural attenuation.

3.2.1.2 *Alternative Evaluation*

Overall Protection

There would be no increased protectiveness of either human health or the environment provided by the No Action alternative. The existing pathways of contaminant exposure for both humans and wildlife would remain, and there would be no mitigation of the risks associated with the site.

Compliance With ARARs

The No Action alternative would provide no remediation of the contaminated media at the site and, therefore, would not meet the potential chemical-specific ARARs or TBCs. There would be no location- or action-specific ARARs associated with this alternative.

Long-Term Effectiveness and Permanence

This alternative would provide no long-term effectiveness since the pathways of contaminant transport and migration, as well as the risks posed by exposure to site contaminants, would remain unchanged. There would be no controls on wastes remaining at the site, other than the limited protection provided by the existing landfill covers.

Reduction of Toxicity, Mobility, or Volume Through Treatment

The No Action alternative provides no treatment for ground water or leachate and therefore does not meet this criterion.

Short-Term Effectiveness

Short-term effectiveness is not applicable to the No Action alternative, since there are no construction activities undertaken .

Implementability

This alternative is currently implemented at the site.

Cost

There are no capital costs associated with this alternative, but O&M costs would be incurred for site maintenance and ground water monitoring, as summarized below:

Capital Cost	$0
O&M Present Worth Cost	$600,000
Total Present Worth Cost	$600,000

State Acceptance

PADER's 2 June 1994 draft FS comment letter implies that this alternative is unacceptable.

3.2.2 *Alternative 2 - Single Barrier Capping, Leachate Collection, and Ground Water Monitoring*

3.2.2.1 *Alternative Description*

In this alternative, a single barrier cap would be installed on both the lined and unlined fill areas, accessible portions of the leachate collection system would be renovated, the debris and drum areas would be cleaned up, and a ground water monitoring system would be established. Cleanup of the debris and drum areas and reconstruction of the leachate collection system would be performed prior to cap construction to allow any contaminated soils to be consolidated in the areas to be capped.

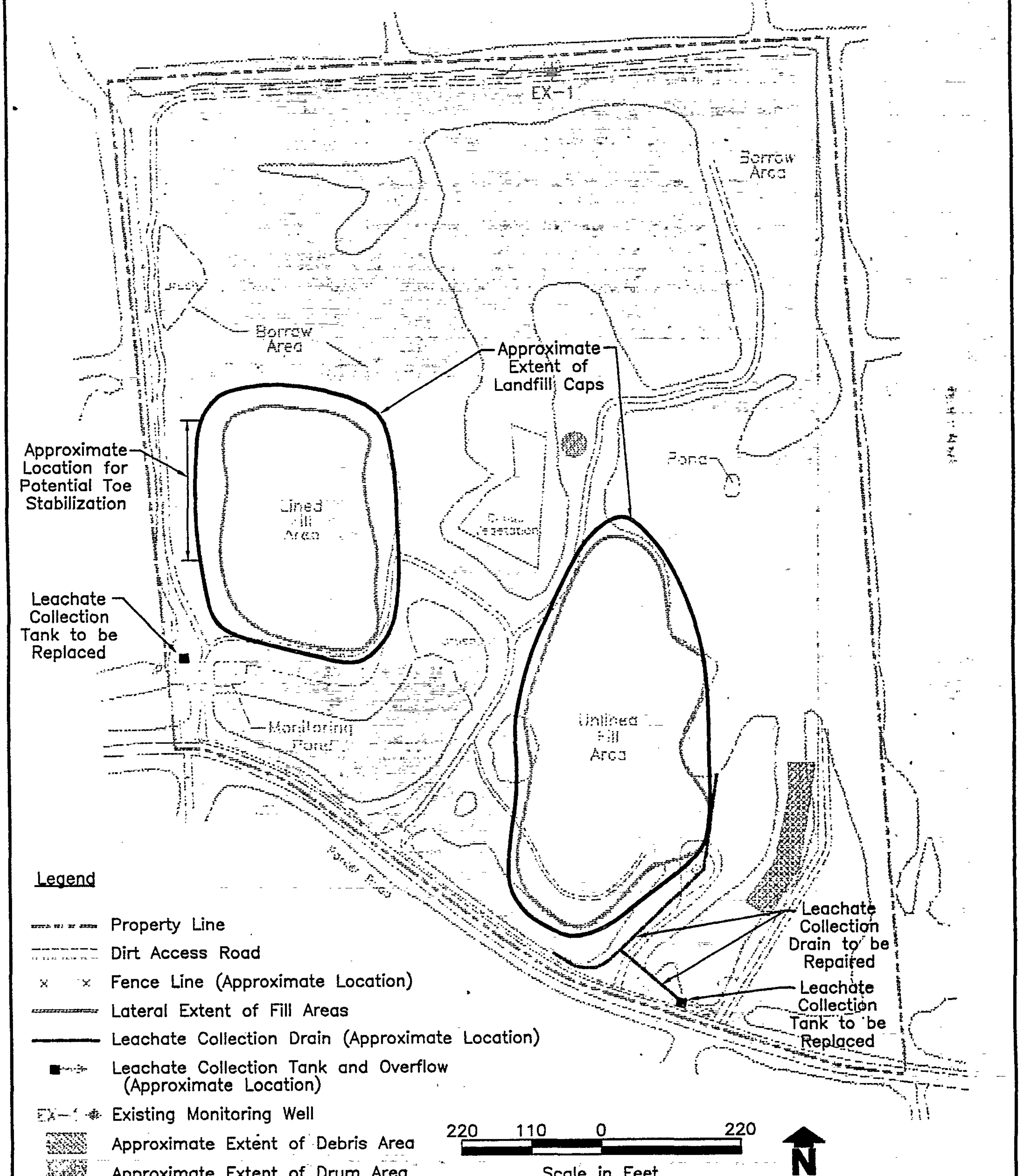
Cleanup of the debris and drum areas would entail removal of the scrap/waste materials and drum carcasses for off-site disposal or recycling. If any intact drums or concentrated waste materials were found in these areas, they would be removed for off-site disposal. Any visibly stained soils in the debris area would be removed and placed in the areas to be capped. A confirmatory soil sampling plan would be developed to ensure that any remaining constituents do not exceed acceptable levels. Grading and revegetation of the debris and drum areas would be performed using indigenous plants as needed to restore the natural appearance of these areas.

Renovation of the leachate collection system would be accomplished by rebuilding the perimeter drain from the unlined fill area to the collection tank, redirecting the monitoring drain discharge at the lined fill area to the leachate collection system and removing the monitoring pond, replacing the existing leachate collection tanks, temporarily installing a new leachate storage tank, and piping the new leachate collection tanks to the new storage tank. Visibly stained soils from the leachate seep areas, from the leachate collection tank overflows and the monitoring pond sediments would be removed (followed by confirmatory sampling) and placed in the areas to be capped. A temporary storage tank would be installed to contain excess leachate and provide a collection point for off-site transportation and disposal of leachate. The temporary storage tank would be used for up to two years following capping, by which time leachate production is expected to decline dramatically. The temporary storage tank would be removed from the site at such time as the leachate collection tanks were able to provide sufficient storage capacity for leachate. Potential disposal options for leachate include the local POTW or a permitted TSD facility. The areas around the leachate collection tanks would be graded and revegetated as needed to restore the natural appearance of these areas.

Once all contaminated soils had been consolidated in the fill areas, cap construction would begin. The two fill areas would be graded to achieve the required slopes for cap placement, with additional fill imported as needed. Although the final cap specifications would be determined during the design phase, a single barrier cap generally consists of a low permeability layer overlain by a drainage or cover soil layer, overlain by a vegetated topsoil layer. A passive gas venting system is included in this alternative, although the actual design of this component will be determined during final design. A conceptual layout of the proposed cap and leachate collection system is shown on Figure 3-1.

Appendix B presents an evaluation of various capping options, including a variety of single barrier caps. Based on this evaluation, two single barrier caps are considered to be the most appropriate for this site: the

Figure 3-1
Conceptual Layout of Capping Alternatives
Bell Landfill
Towanda, Pennsylvania



PADER-type cap (Alternative 2a) and the alternate ERM VE cap (Alternative 2b). The final details of the actual single barrier cap to be used will be defined during the remedial design stage. As discussed in Appendix B, an equivalency review would be requested if it is determined that the ERM VE cap design is the most appropriate.

At the completion of all construction activities, a long-term O&M plan would be developed and implemented for the site. This would include maintenance of the caps and leachate collection system; installation and maintenance of any access restrictions, such as perimeter fencing, deemed necessary to protect the integrity of the site; and performance of both on-site and residential ground water monitoring. Indigenous shrubs will be planted around the landfill areas such that an impassable barrier develops over time. Deed restrictions to prevent future use of on-site ground water and control access to the site would also be implemented.

While ground water recovery and treatment is not part of this alternative, The need for ground water treatment at the site will be evaluated at the end of five years. This is consistent with CERCLA requirements for a review of the effectiveness of a selected remedy following five years of performance. To assist in the evaluation, data from both the on-site monitoring wells and the adjacent residential wells will be reviewed to determine trends in ground water quality.

During the five year period following capping, the on-site monitoring wells will be samples and analyzed quarterly for a list of indicator parameters including VOCs, manganese and wet chemistry parameters which are indicative of the processes of natural degradation. For example, a decrease in the concentration of TCE and an increase in concentration of vinyl chloride would be indicative of ground water quality improvement as the natural breakdown of TCE occurs following capping.

The off-site residential wells have been samples on three occasions in the past including July 1983 and March 1989 by PADER and September 1992 by ERM. In all instances, no site related constituents were reported. Accordingly, the residential wells will be samples for VOCs and metals on an annual basis during the five year period following remediation. The results from these analyses will be used to determine if there continues to be no unacceptable risk to the off-site residential receptors from site related constituents. If the data continues to show no site related impact, the residential sampling frequency will be reduced to bi-annually

3.2.2.2 *Alternative Evaluation*

Overall Protection

This alternative would be protective of human health and the environment by eliminating the existing pathways of contaminant exposure at the site. Consolidation of contaminated soils under the new caps, along with renovation of the leachate collection system and the reduction in leachate production resulting from cap placement, would prevent direct contact with contaminated soils and leachate. Residential wells are not currently impacted by conditions at the site, and future impacts are not expected, particularly under conditions of reduced infiltration and leachate generation once the fill areas are capped. While there is no evidence of off-site migration of contaminants in ground water, capping and leachate collection would also minimize the potential for any such migration to occur. Future direct contact with on-site ground water would be prevented through implementation of deed restrictions, and the significant reduction in leachate generation would allow natural attenuation to reduce contaminant levels in ground water over time.

Compliance With ARARs

This alternative would potentially achieve all ARARs for the site over time. The cap would be designed to meet or exceed the PADER cap requirements, and the ground water at the site would likely reach MCLs as a result of natural attenuation over time once the caps were installed and leachate production was minimized. There are no location-specific ARARs, and compliance with the action-specific ARARs would be achieved through adherence to the required standards during alternative implementation.

Long-Term Effectiveness and Permanence

This alternative would provide a significant degree of long-term effectiveness and permanence. A cap in conjunction with the renovated leachate collection system would reduce leachate generation and contaminant mobility and eliminate the risks associated with direct contact for as long as the systems were properly maintained. Routine site inspections, mowing of the vegetative cover, and prompt repairs would maximize the life of the cap. The leachate collection system would be maintained through routine equipment inspections and regular removal of accumulated leachate from the storage tank/collection tanks.

The risks associated with direct contact with ground water would be reduced through institutional controls, such as deed and access restrictions to prevent future on-site well construction, and through natural attenuation over time. Negotiations between the SCs and the property owner to implement deed and access restrictions are currently underway.

Reduction of Toxicity, Mobility, or Volume

There would be some reduction of contaminant toxicity, mobility, and volume through treatment of the collected leachate. There would also be a significant indirect reduction of contaminant mobility due to cap placement and a reduction in contaminant toxicity and volume due to natural attenuation and degradation of contaminants over time.

Short-Term Effectiveness

There would be essentially no expected adverse impacts to human health and the environment during implementation of this alternative. Soil removal and capping would result in a minimal increase in contaminant exposure during construction through direct contact with contaminated soils and fugitive dust emissions, although any risks to on-site workers would be minimized by the use of personal protection gear. Contaminant exposure would be reduced once the foundation layer of the cap was installed.

Renovation of the leachate system would also result in a minimal increase in contaminant exposure, but this exposure would be of very short duration and workers would use personal protection gear. There would be no significant impacts associated with the other site remediation activities.

Implementability

This alternative could be easily implemented at the site. The materials, labor, equipment, and services needed to remove and consolidate contaminated soils, renovate the leachate collection system, remove debris from the site, install new caps on the fill areas, and institute ground water monitoring are readily available, and the technologies to be used are proven and reliable. There would be no permits required to implement this alternative, but implementation of the ground water and site use restrictions would require cooperation among various governmental agencies, such as PADER and county and township officials. Compliance with the substantive requirements for cap construction under Pennsylvania regulations would also be required.

Cost

Capital costs would be incurred primarily for installation of the caps. The primary O&M costs are associated with leachate disposal and ground water monitoring. The estimated costs of alternative implementation are summarized as follows:

Alternative 2a: PADER-type cap

Capital Cost	$1,970,000
O&M Present Worth Cost	<u>$1,160,000</u>
Total Present Worth Cost	$3,130,000

Alternative 2b: ERM VE cap

Capital Cost	$1,760,000
O&M Present Worth Cost	<u>$1,160,000</u>
Total Present Worth Cost	$2,920,000

State Acceptance

This alternative is acceptable to PADER based upon their draft FS comment letter of 2 June 1994.

3.2.3 *Alternative 3 - Composite Barrier Capping, Leachate Collection, and Ground Water Collection and Treatment*

3.2.3.1 *Alternative Description*

This alternative includes all the components of Alternative 2 except that a composite barrier cap, rather than a single barrier cap, would be constructed on the lined and unlined fill areas (Figure 3-1), and a ground water recovery and treatment system would be installed. A description of those components of Alternative 3 not included in Alternative 2 is provided in the following paragraphs.

The composite barrier cap is similar to the single barrier cap except that an additional impermeable layer is included. A typical composite barrier cap includes two impermeable layers overlain by a drainage layer, overlain by a cover soil layer, overlain by a vegetated cover. For the purpose of this evaluation, installation of a RCRA-type cap, as described in Appendix B, is assumed.

Ground water recovery and treatment would also be included in this alternative. For the purposes of this FS, it is assumed that five new wells yielding a total of 4 gpm would be installed in the southeast corner of the site. Assuming that data collected from monitoring wells MW-3 and MW-6 are representative of ground water quality in this area of the site, the ground water recovered for treatment would contain an average of approximately 50 μg/L of total volatile organic compounds, 1.3 mg/L (total) manganese, and 40 mg/L (total) iron.

The recovered ground water would be pumped to a central, on-site treatment facility. Although treatability testing would be required prior to treatment system design, this evaluation assumes that chemical precipitation would be used for manganese and iron removal and carbon absorption would be used for organics removal. The treated water would be discharged to the eastern tributary at the site, as reinjection is not generally feasible in a bedrock formation with low hydraulic conductivity.

Although this alternative is evaluated under the assumption that leachate would be collected for off-site treatment and disposal, it is possible that the collected leachate could be treated in the on-site ground water treatment system. On-site leachate treatment will be evaluated in detail during the design phase if ground water treatment is to be implemented at the site.

3.2.3.2 *Alternative Evaluation*

Overall Protection

This alternative would provide protectiveness essentially equivalent to that provided by Alternative 2, since all contaminant exposure pathways would be eliminated. Although this alternative could theoretically provide enhanced protectiveness by reducing contaminant levels in the aquifer in less time through pumping and treatment than through natural attenuation, there is no evidence of off-site contaminant migration and there are no receptors for on-site ground water, and this additional future protectiveness is purely hypothetical.

Compliance With ARARs

Like Alternative 2, this alternative could potentially achieve all ARARs for the site over time. The ground water at the site could reach MCLs as a result of long-term ground water recovery once the caps were installed and leachate production was minimized. However, due to the low hydraulic conductivity, it is not likely that ground water would be remediated any sooner than through natural attenuation. There are no location-specific ARARs for this alternative, and compliance with the action-specific ARARs would be achieved through adherence to the required standards during alternative implementation.

Long-Term Effectiveness and Permanence

This alternative would provide long-term effectiveness and permanence. Installation of the caps and leachate collection system and operation of the ground water recovery and treatment system would reduce leachate generation and contaminant mobility and eliminate the risks associated with direct contact for as long as the systems were properly maintained. During the time required to restore the aquifer to background conditions, the risks associated with direct contact with on-site ground water would be reduced through institutional controls, such as deed and access restrictions to prevent future well construction on site.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Contaminant toxicity, mobility, and volume in the ground water and leachate would be reduced under this alternative. The mobility of all constituents would be reduced through ground water recovery and leachate collection, and the volume and toxicity of the organic constituents would be reduced through treatment. However, the bedrock at the site has a low hydraulic conductivity, and slow contaminant migration and low well yields are expected, likely resulting in a long time frame to remove a significant mass of contaminants from the aquifer.

Short-Term Effectiveness

There would be essentially no expected adverse impacts to human health and the environment during implementation of this alternative. Soil removal, capping, renovation of the leachate collection system, and installation of the ground water collection and treatment system would result in a minimal increase in contaminant exposure during construction, and any risks to on-site workers would be minimized by the use of personal protection gear. There would be no significant impacts associated with the other site activities.

Implementability

This alternative could be implemented at the site. The materials, labor, equipment, and services needed to install all the components of this remedy are readily available, and the technologies to be used are proven and reliable. However, the technical feasibility of ground water recovery is questionable. During the RI, the bedrock formation at the site was characterized as having a low hydraulic conductivity, and well yields were typically less than 2 gpm. The migration of contaminants into ground water and the flow rate of the ground water itself are both very slow. The zone of influence of any one well is expected to be small, and the likelihood of establishing hydraulic control over ground water at the site is believed remote. Furthermore, contaminant concentrations in ground water are currently low, with marginal exceedances of MCLs reported for only a few compounds. Once the caps are installed and equilibrium is reached, contaminant transport from the fill areas to the ground water is expected to decrease to a negligible rate, such that ground water concentrations are expected to decrease through natural attenuation. In addition, cap placement could result in significantly reduced flows to the recovery wells, such that ground water collection becomes infeasible.

While no permits for on-site activities would be required, an NPDES permit for off-site discharge of treated ground water would be needed, and implementation of the ground water and site use restrictions would require cooperation among various governmental agencies. Compliance with the substantive requirements for cap construction under Pennsylvania regulations would also be required.

Cost

Capital costs would be incurred primarily for installation of the caps and the ground water collection and treatment system. The primary O&M costs are associated with leachate disposal and long-term ground water treatment and monitoring.

The estimated costs of alternative implementation are summarized as follows:

Capital Cost	$3,040,000
O&M Present Worth Cost	$1,560,000
Total Present Worth Cost	$4,600,000

State Acceptance

PADER's 2 June 1994 draft FS comment letter implies that this alternative is acceptable.

3.3 *COMPARATIVE EVALUATION OF ALTERNATIVES*

This section presents a comparative analysis of the alternatives, criterion by criterion. Table 3-1 at the end of this section summarizes the comparison.

3.3.1 *Overall Protection of Human Health and the Environment*

No Action would provide no protection of human health and the environment other than what would be achieved over time through natural attenuation of contaminants. Alternatives 2 and 3 would provide essentially equivalent levels of protectiveness. A well-designed single barrier cap, such as the ERM-VE cap, can achieve performance equivalent to that of a composite barrier cap. A composite barrier cap or the enhanced single barrier cap achieves a lower permeability and leachate generation rate than the PADER cap, as shown in Appendix B.

The protectiveness provided by ground water recovery and treatment under Alternative 3 is not significantly greater than that provided by reduction of leachate production and natural attenuation under Alternative 2 for the following reasons:

- there are currently no exposure routes to contaminated ground water at the site;
- a long time frame would likely be required for ground water recovery to significantly reduce contaminant levels in the aquifer;
- it is unlikely that ground water recovery will significantly expedite ground water cleanup; and
- there are no receptors who are likely to be impacted by site ground water in the future.

3.3.2 *Compliance with ARARs*

The No Action alternative would not achieve the chemical-specific ARARs/TBCs for the site, as leachate generation would not be reduced and ground water standards would not be met. Alternatives 2 and 3 are expected to meet all ARARs and TBCs for the site through capping and long-term ground water remediation (either natural attenuation or recovery and treatment) and by conducting remedial activities in accordance with the appropriate action-specific ARARs.

3.3.3 *Long-Term Effectiveness and Permanence*

No Action would provide no long-term effectiveness and permanence, since no remediation of existing site conditions would occur. Alternatives 2 and 3 would provide equivalent effectiveness and permanence because the pathways for direct contact with contaminated media would be eliminated. The potential risks associated with ingestion of contaminated ground water would be permanently reduced over time under both alternatives. Although Alternative 3 could potentially shorten the time required for aquifer restoration, it is more likely that both ground water recovery and natural attenuation will require a long time frame to achieve MCLs or background levels in on-site ground water.

3.3.4 *Reduction of Toxicity, Mobility, or Volume Through Treatment*

No Action would provide no reductions in contaminant toxicity, mobility, or volume. Alternatives 2 and 3 would reduce leachate toxicity, mobility, and volume through collection and treatment and would also provide indirect reduction of contaminant mobility through capping and reduced leachate generation. Alternative 3 would further provide some reduction in ground water toxicity, mobility, and volume over time, depending on the mass of contaminants removed from the aquifer by ground water recovery.

3.3.5 *Short-Term Effectiveness*

This criterion is not applicable to the No Action alternative. The short-term effectiveness of Alternatives 2 and 3 is essentially equivalent, although construction of a composite barrier cap and installation of the ground water recovery and treatment system under Alternative 3 could extend the time required for implementation and increase the potential short-term risk. Both alternatives would be completed within relatively short time frames with minimal impacts to the community, workers, and the environment.

3.3.6 *Implementability*

No Action is currently implemented at the site. The implementability of all components of Alternatives 2 and 3 are essentially equivalent, with the exception of ground water recovery. Alternative 2 would be more readily implementable than Alternative 3 because of the questionable feasibility of installing an effective ground water recovery system at the site.

3.3.7 *Cost*

The only costs associated with the No Action alternative are for long-term site maintenance and ground water monitoring. The total present worth cost of Alternative 1 is $600,000; the total costs for Alternatives 2a, 2b, and 3 are $3,130,000, $2,920,000, and $4,600,000, respectively. Alternatives 2a and 2b are significantly more cost effective than Alternative 3, because they provide essentially equivalent performance and protectiveness at a much lower cost. The higher cost of Alternative 3 is due to the use of a composite barrier cap rather than a single barrier cap and the installation of the ground water recovery and treatment system.

3.3.8 *State Acceptance*

PADER's 2 June 1994 letter implies that a single barrier cap (Alternative) 2 is the minimum acceptable alternative.

3.3.9 *Community Acceptance*

Community acceptance will be evaluated prior to remedy selection.

Table 3-1
Summary of Alternative Evaluation

	Alternative 1	Alternative 2	Alternative 3
Alternative Description	• No further remedial actions • Maintenance of existing soil covers and fencing • Potential ground water monitoring	• Single barrier cap installed on lined and unlined fill areas • New perimeter drain at unlined fill area • New leachate collection tanks at both fill areas • Debris and scrap materials removed from drum and debris areas • Site graded and revegetated • Ground water monitoring instituted • Passive landfill gas collection and migration monitoring	• Composite barrier cap installed on lined and unlined fill areas • New perimeter drain at unlined fill area • New leachate collection tanks at both fill areas • Debris and scrap materials removed from drum and debris areas • Site graded and revegetated • Ground water collection with on-site treatment for organics and metals removal • Ground water monitoring instituted • Passive landfill gas collection and migration monitoring
Overall Protection of Human Health and the Environment	• No increased protectiveness of human health or the environment	• Existing pathways of contaminant exposure at site eliminated • Protective of human health and the environment	• Existing pathways of contaminant exposure at site eliminated • Protective of human health and the environment
Compliance with ARARs	• ARARs not achieved	• Achieves site ARARs	• Achieves site ARARs
Long-Term Protectiveness	• No reduction in existing risks associated with exposure to the site	• Significant long-term effectiveness and protectiveness through reduction in risks associated with direct contact	• Significant long-term effectiveness and protectiveness through reduction in risks associated with direct contact
Reduction of Toxicity, Mobility, or Volume ThroughTreatment	• None	• Reduction in leachate T, M, and V through collection and treatment • Indirect reduction in contaminant mobility through capping and reduction of leachate generation	• Reduction in leachate T, M, and V through collection and treatment • Reduction in T, M, and V in ground water through recovery and treatment
Short-Term Effectiveness	• Not applicable	• Minimal expected impacts to workers, community, and the environment	• Minimal expected impacts to workers, community, and the environment
Implementability	• Currently implemented	• All components readily implementable at site	• All components except ground water recovery readily implementable at site • Necessity/implementability/practicality of ground water recovery questionable
Cost	• $600,000	• $3,130,000 (2a) • $2,920,000 (2b)	• $4,600,000
State Acceptance	• Unacceptable	• Acceptable	• Acceptable

4.0 SUMMARY AND CONCLUSIONS

4.1 SUMMARY

The site is situated in a sparsely populated rural setting with approximately 99 residents living within one mile of the site. Five residences in close proximity to the site rely on individual wells for drinking water. The two, three-acre municipal waste fill areas on site have been the source of uncontrolled leachate discharges for the past 12 years, with the unlined landfill in existence since 1969. In 1991, EPA's Removal Section determined that the site did not present an imminent threat to health or the environment and did not warrant an interim remedial action. A subsequent RI completed by the Settling Companies in 1993 has further corroborated the lack of significant adverse impact and unacceptable risk as demonstrated by the following:

- No residential wells have been impacted by site-related constituents. This conclusion is consistent with a 1989 sampling event conducted by PADER that also concluded that there is a lack of site-related impact to residential wells. EPA's risk assessment has shown that no unacceptable risk attributed to the site is present from residential water quality.
- Ground water discharge from the site has not impacted the two adjacent surface water tributaries with one possible exception. As reported following a 1985 PADER stream survey, one stream sampling station in the eastern tributary exhibited a depressed macroinvertebrate population. This may be the result of ground water discharge to the tributary or the result of natural stream conditions. No site-related constituents were detected in the surface water or sediment, however, and EPA's risk assessment showed no unacceptable risk associated with either surface water or sediments.

The RA did show, however, that on-site leachate seeps result in unacceptable risk both under current site conditions and under realistic future site-use scenarios. Although the site is fenced and undeveloped, both the current and future use scenarios include exposure to leachate by child trespassers and adult hunters. However, these potential exposure pathways and the associated risk will be eliminated by soil removal, site capping, and leachate management.

4.2 *CONCLUSIONS*

This FS evaluates a range of remedial technologies to address the conditions at the site. Based on the detailed evaluation of alternatives conducted in Section 3.2 and the comparative evaluation conducted in Section 3.3, the Settling Companies and ERM strongly believe that Alternative 2, which includes single barrier capping, leachate management, soil consolidation, and ground water monitoring, should be implemented at the site. This alternative is the most practical, cost effective, and easily implementable remedy because it provides:

- no significant adverse impact off site,
- no unacceptable off-site risk,
- relatively minimal impacts on site, and
- ready minimization of unacceptable on-site risk under realistic future use scenarios.

Alternatives 2 and 3 meet ARARs and provide overall protection of human health and the environment both in the short and long term. Any additional protectiveness potentially provided by ground water recovery and treatment under Alternative 3 is not significant when the feasibility of recovering significant contaminant mass is low and there are no current or likely future users of ground water at the site. Furthermore, leachate generation is predicted to decrease to a negligible rate within six to twelve months following cap installation, at which time natural attenuation may be as effective as ground water recovery in reducing contaminant mass levels in the aquifer.

In the future use scenario, one unacceptable risk that will not be immediately eliminated by capping and leachate collection is exposure to contaminated ground water on site. Several VOCs and manganese are present in ground water at elevated concentrations, primarily in the southeastern corner of the site. The installation of a drinking water well at the former landfill site would result in unacceptable risk to the water users. Unlike exposure to leachate stained soils and seeps, which are realistic future exposure points even though they will be eliminated under Alternative 2, exposure to contaminated ground water is a potential future exposure point. However, the implementation of appropriate institutional controls, such as deed restrictions to prohibit the installation of water supply wells, will eliminate this potential future exposure point, thus making the recovery and treatment of ground water unnecessary. Off-site migration of contaminants in ground water has not been detected.

As stated in previous sections of this report, the recovery of contaminated ground water at the site will be difficult because of the poorly fractured bedrock and its low hydraulic conductivity. The bedrock flux beneath the unlined fill area is very low, calculated to be approximately one gallon per minute (Appendix A). The highest total VOC concentration (MW-6) is 0.075 mg/L. The resultant VOC mass flux is only 0.3 mg/sec. Even if this value were to increase an order of magnitude because of fractured bedrock heterogeneity, the value is extremely low. The ability of contaminants to migrate in the bedrock system is also minimized because of the low ground water flow velocities. Furthermore, contaminant flux will be reduced following installation of the low permeability cap. The current leachate generation rate for the unlined fill area is approximately 2,000 gpd. Following cap installation, the leachate generation rate is expected to decrease to less than 1 gpm. Therefore, the ability to remove significant contaminant mass from the low yielding bedrock system is poor at best. Equivalent mass removal will likely occur without ground water recovery and treatment through natural attenuation.

In conclusion, ground water recovery and treatment is impractical, given the absence of unacceptable risk under current and realistic future use scenarios, the likely removal of only small masses of contaminants, the reported absence of off-site contaminant migration in ground water, the significant reduction in contaminant transport to ground water expected following capping, and the ability to control future exposures to site ground water through deed restrictions.

Appendix A
Ground Water Flux Calculations

Environmental Resources Management, Inc.

ERM

WO Number	C0402.18.01	Sheet	1 of 3
Project	Bell Landfill FS		
Subject	GW flux		
By	J LaRegina	Date	4-20-94
Chkd by	[illegible]	Date	4-22-94

Calculation of bedrock flux beneath unlined fill area between wells MW-4 upgradient and wells MW-3 + MW-6 Downgradient.

$Q = kia$

where:

Q = bedrock flow (gpm)

k = hydraulic conductivity (ft/day)

i = hydraulic gradient (ft/ft)

a = crossectional flow field area (ft^2)

K = 0.15 ft/day MW-4
0.005 ft/day MW-3
0.009 ft/day MW-6

use 0.15 ft/day most conservative

i = measured between MW-4 and MW-3/6

A = 450 ft × 80 ft = 36,000 ft^2

450 ft = width of flow field beneath landfill

80 ft = saturated thickness (conservative)

see attached figures

$Q = (0.15 \text{ ft/day})(0.04 \text{ ft/ft})(36{,}000 \text{ ft}^2)$

$= 216 \text{ ft}^3/\text{day}$

or 1.1 gpm

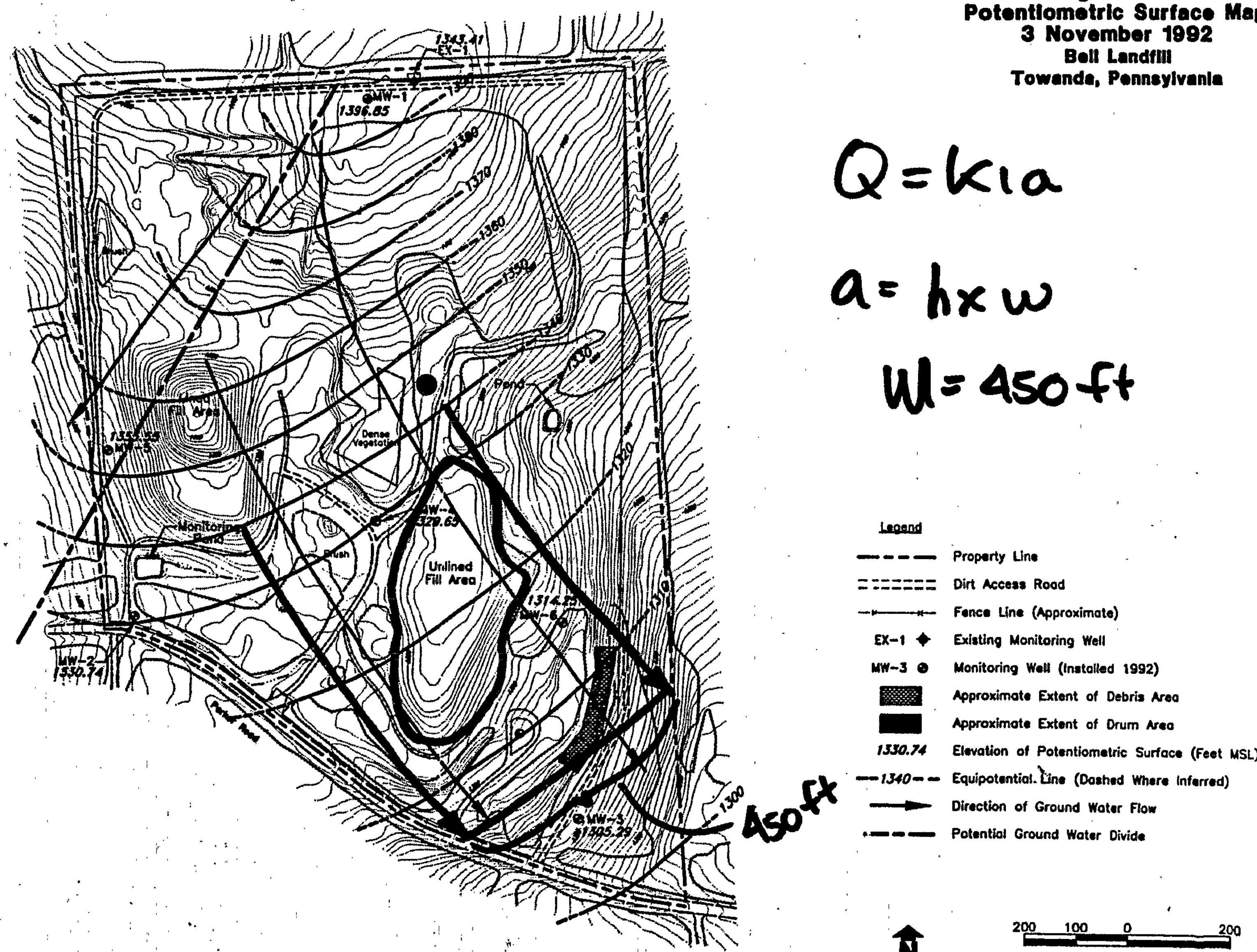
2 of 3

Figure 3-14
Potentiometric Surface Map
3 November 1992
Bell Landfill
Towanda, Pennsylvania

$Q = KIA$

$a = h \times w$

$W = 450\text{ ft}$



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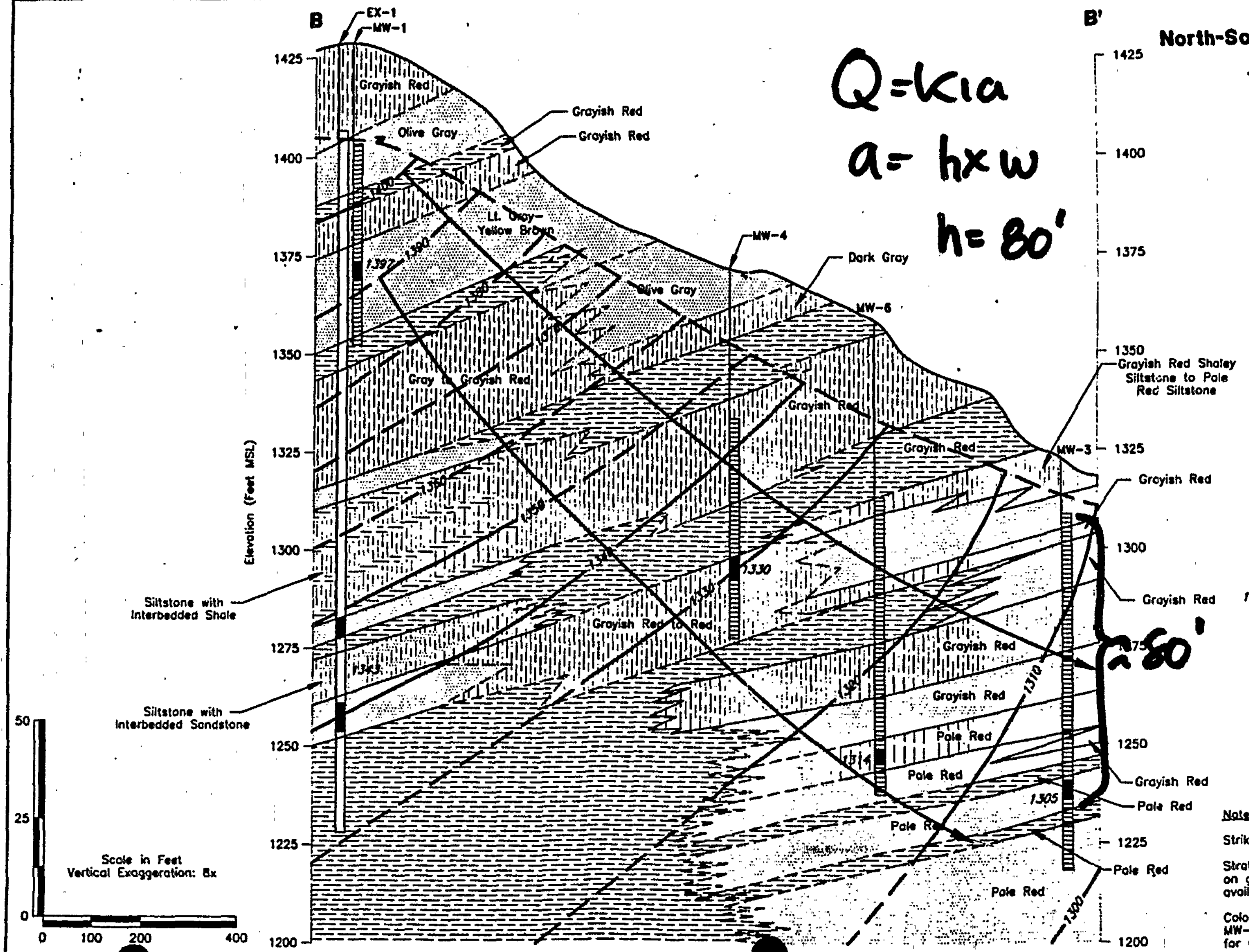
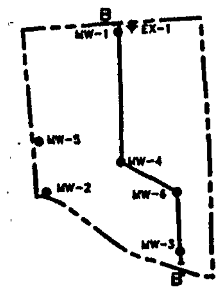
3 of 3

Figure 3-12
North-South Geologic Cross Section
Bell Landfill
Towanda, Pennsylvania

Q=KIA
a= h x w
h= 80'





Legend

- Sandstone
- Siltstone
- Shale
- 1397 Screened Interval of Monitoring Well Showing Potentiometric Elevation and Water Bearing Zone
- Potentiometric Surface
- Facies Change
- Contact Between Lithostratigraphic Units (Dashed where Inferred)
- —1320— Equipotential Lines (Dashed Where Inferred, 3 November 1992 Data)
- Direction of Ground Water Flow

Notes:

Strike is north 13° east. True dip is 3° northwest.

Stratigraphic correlations at well EX-1 based on geophysical logs only. Lithologic log not available for this well.

Color descriptions are as observed in wells MW-1, MW-3 and MW-6. No color description available for well EX-1.

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C8402 18 01/07 28 93-DST/12 06 93-DST/E2OJ

Appendix B
Evaluation of Cap Performance

1.0 INTRODUCTION

This appendix has been prepared to present a detailed evaluation of various capping alternatives for the Bell Landfill site in Towanda, PA. This evaluation was conducted to support the Feasibility Study (FS) for the lined and unlined landfills at the site and to aid in the selection of the most appropriate cover design for these landfills.

2.0 DISCUSSION OF CAPPING ALTERNATIVES

As presented in Section 2.4.3 of the FS, a number of capping designs are potentially applicable for remediation of the Bell Landfill site. In particular, this evaluation has considered the following three general capping types: 1) soil cover; 2) single barrier; and 3) composite barrier. A discussion of these various capping alternatives is presented below.

2.1 Soil Cover

A soil cover generally consists of a layer of clean soil fill covered by a thin topsoil layer. The surface of the soil cover is generally graded to control surface water runoff and reduce infiltration and vegetated to reduce erosion. A soil cover contains waste by reducing the potential for direct contact with exposed waste, by reducing the infiltration of surface water and subsequent leachate generation, and by reducing the potential for migration of waste from erosion. This evaluation considers a 2-foot thick vegetated soil cover consisting of 18 inches of general fill and 6 inches of topsoil. Based on the Remedial Investigation (RI) Report, the landfills are currently capped with native soils ranging in thickness from less than 1 foot to greater than 2 feet with fairly well-vegetated surfaces.

2.2 Single Barrier

A single barrier cap, as presented herein, refers to a cover system that includes one impermeable barrier layer in combination with various other layers as appropriate. An impermeable barrier layer, as presented herein, refers to a layer of clay with a minimum thickness of 12 inches and a maximum hydraulic conductivity of 1×10^{-7} cm/sec, a synthetic flexible membrane liner (FML), or any similar low-permeability barrier. Other layers which may be appropriate in combination with a single barrier include soil bedding layers beneath the barrier (particularly for the protection of FMLs), gas collection layers, drainage layers (granular or synthetic materials), protective cover layers, and topsoil layers.

Single barrier caps generally consist of, from bottom to top, a low-permeability barrier layer, a drainage layer, and a vegetated cover soil layer. The required final cover for municipal waste landfills in Pennsylvania, as presented in 25 Pa. Code, Section 273.234, is a type of single barrier cap. The typical cap design specified by PADER in the regulations (typical PADER-type cap) generally includes the following layers (from bottom to top):

- One-foot thick compacted fill as subgrade or intermediate cover,
- One-foot thick clay liner,
- One-foot thick sand drainage layer,
- Two-foot thick cover soil, and
- Vegetated cover.

Based on the requirements of 273.234, an acceptable variation of the typical PADER-type cap (alternate PADER-type cap) includes the following layers (from bottom to top):

- One-foot thick compacted fill as subgrade or intermediate cover,
- 30-mil (or thicker) FML,
- Geocomposite (geonet and geotextile fabric) drainage layer,
- Two-foot thick cover soil, and
- Vegetated cover.

A third single barrier capping design is also considered in this FS. This particular cap design is a value-engineered (VE) cap, which has been developed by ERM to provide a level of effectiveness similar to that of more expensive composite barrier caps (e.g., typical RCRA-type caps) but at a much lower cost. In general, this cap design includes the following layers (from bottom to top):

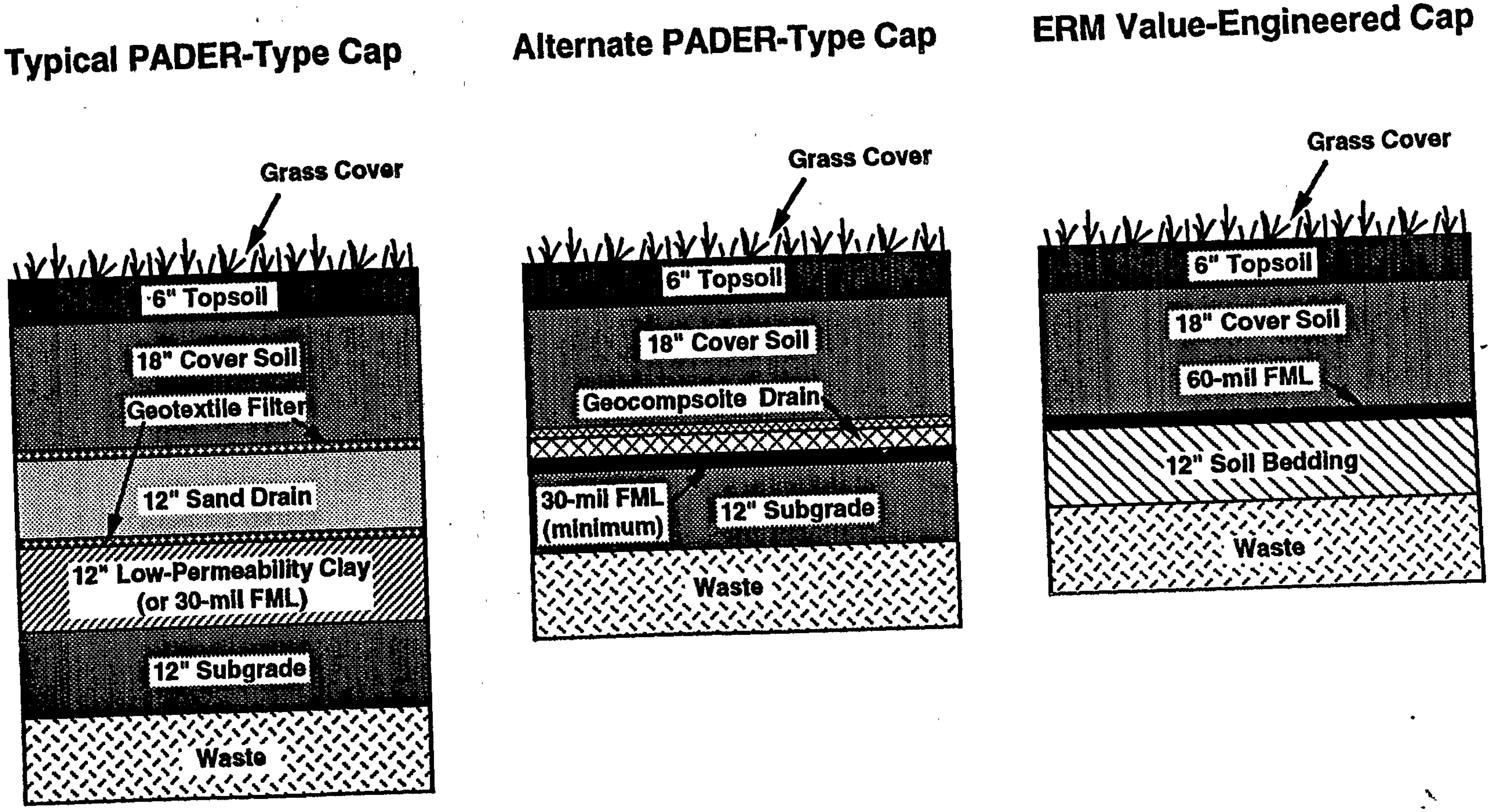
- One-foot thick low-permeability soil bedding layer,
- 60-mil FML,
- Two-foot thick cover soil, and
- Vegetated cover.

A generalized representation of the two single barrier capping options considered in this report is presented in Figure 1.

2.3 *Composite Barrier*

A composite barrier cap, as discussed herein, refers to a cap that includes two or more impermeable barrier layers. A common composite barrier is the typical RCRA-type cap recommended by the EPA for hazardous waste landfills ("Final Covers on Hazardous Waste Landfills", EPA/530-SW-89-

Figure 1
Single Barrier Caps
Bell Landfill
Towanda, PA



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047). This type of cap is generally considered to be more effective at restricting infiltration than a single barrier cap, although some single barrier caps can achieve essentially equivalent performance. The composite cap considered in this evaluation includes the following layers (from bottom to top):

- Two-foot thick clay liner,
- 30-mil FML,
- One-foot thick sand drainage layer,
- Two-foot thick cover soil, and
- Vegetated cover.

A generalized representation of the composite barrier cap considered in this report is presented in Figure 2.

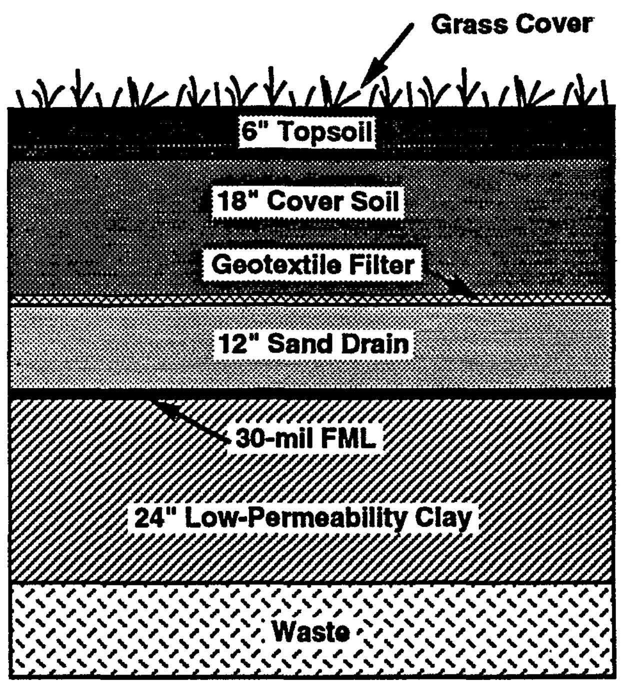
3.0 *COMPARATIVE PERFORMANCE EVALUATION*

This comparative evaluation considers the five cap types discussed above: 1) soil cap; 2) typical PADER-type cap; 3) alternate PADER-type cap; 4) ERM VE cap; and 5) RCRA-type cap. All of these caps are expected to have similar effectiveness in meeting the secondary performance criteria, e.g., minimal maintenance, erosion control, long-term integrity, and surface water control, due to their similarity with respect to cover soil, surface vegetation, surface slopes, waste, and management conditions. Minor variations (e.g., addition of a drainage layer) may be required in some cases to achieve the desired level of performance. For the Bell Landfill site, however, the most important difference in the caps is their ability to reduce infiltration and leachate generation. This difference is the focus of this evaluation.

The average annual percolation of precipitation through landfill caps can be estimated with a computer program developed specifically for this purpose (HELP or Hydrologic Evaluation of Landfill Performance by Schroeder, et al., 1984, EPA/530-SW-84-010 - Version 2.05, 1989). The HELP program calculates the amount of water infiltrating through a cap based on the given cap design features and climatological data. Climatological data for a city located just north of Towanda (Ithaca, NY), was used for the evaluation, although the generation of daily solar radiation values was adjusted to reflect the actual latitude of the Bell Landfill site. Default soil characteristics were used to represent the soil types used in each type of cap. For this evaluation, the two-foot thick cover soil layer was divided into a 6-inch topsoil layer and an 18-inch layer of general fill. For the caps that include a geomembrane liner, the liner leakage factors (i.e., the fractional area of the liners through which leakage may occur) used are based on recommended values. A lower

Figure 2
Composite Barrier Cap
Bell Landfill
Towanda, PA

Typical RCRA-Type Cap



liner leakage factor was used for the thicker membrane to reflect the greater durability and lower probability of leakage. For evaluation of the alternate PADER-type cap, a 60-mil FML was considered as an example (the final remedial design, however, will determine whether a liner thicker than the required 30-mils is appropriate).

The key input and output parameters from the HELP model runs are presented in Table 1, and the complete HELP output summary sheets are presented in Attachment B-1. The total volume of infiltration through each of the caps was estimated by taking the average annual percolation through the cap (in inches) and multiplying it by the area for each of the two landfills at the site.

Based on the HELP results summarized on Table 1, single barrier caps can significantly reduce the volume of surface water infiltration and leachate generation as compared to a two-foot soil cover. Also, if designed and constructed properly, a single barrier cap similar to the alternate PADER-type cap or the ERM VE cap can achieve a level of performance similar to that of much more expensive composite barrier caps such as a RCRA-type cap.

The following considerations have been included in the evaluation:

- A relatively thick (60-mil), heavy duty FML was considered for the primary liner for the alternate PADER-type cap and the ERM VE cap. The typical thickness of FMLs required for capping applications is 30 to 40 mils, although the performance of a 60-mil liner is generally superior to that of thinner liners due to generally greater puncture resistance and better survivability during construction, resulting in less damage and less leakage through the liner. The incremental cost of 60-mil liners over thinner liners is relatively small, once factors such as delivery, installation and testing are included. The actual liner thickness to be used for the alternate PADER-type cap (i.e., 30-mil or thicker) would be decided during the final design stage.
- The drainage layer (e.g., sand layer or geonet drain) is considered to generally be unnecessary in some cases, and has been eliminated from the ERM VE cap section since the heavy-duty, thick membrane can prevent surface water percolation regardless of the presence of the drainage layer. Although the HELP model results indicate that the cover soils for the ERM VE Cap may become saturated, this would be only a short-term condition, and would not necessarily jeopardize the stability of the cap, especially on slopes less than 4H:1V (this result is also considered to reflect a limitation of the computer program). The role of the drainage layer is generally only important when a clay layer is used as the primary barrier or when drainage is necessary on steep slopes to improve stability (as may be the case for certain cap

Table 1
COMPARISON OF CAP DESIGNS

KEY CAP COMPONENTS

Soil Cover	Single Barrier Caps			Composite Cap
Typical	PADER-Type A	PADER-Type B	ERM VE Cap	RCRA-Type
6" Topsoil K= 8.0x10-4	*6" Topsoil* K= 8.0x10-4	*6" Topsoil* K= 8.0x10-4	*6" Topsoil* K= 8.0x10-4	*6" Topsoil* K= 8.0x10-4
18" Cover Soil K=3.6x10-5	*18" Cover Soil* K=3.6x10-5	*18" Cover Soil* K=3.6x10-5	*18" Cover Soil* K=3.6x10-5	*18" Cover Soil* K=3.6x10-5
	12" Sand K=1.7x10-3	*Geonet Drain* K=25	*60 mil Liner* LF=1.0x10-4	*12" Sand* K=1.7x10-3
	12" Clay K=1.0x10-7	*60 mil Liner* LF=1.0x10-4	*12" Soil Bedding* K=2.1x10-6	*30 mil Liner* LF=1.0x10-3
	12" Fill K=7.2x10-4	*12" Fill* K=7.2x10-4		*24" Clay* K=1.0x10-7

K = Hydraulic Conductivity (cm/sec); LF=Liner Leakage Fraction

SUMMARY OF "HELP" RESULTS (Average Annual Totals)

	Soil Cover	Single Barrier Caps			Composite Cap
	Typical	PADER-Type A	PADER-Type B	ERM VE Cap	RCRA-Type
Precipitation	40.16 in. (100%)	40.16 in. (100%)	40.16 in. (100%)	40.16 in. (100%)	40.16 in. (100%)
Runoff	0.33 in. (0.81%)	0.82 in. (2.04%)	0.33 in. (0.81%)	6.97 in. (17.37%)	1.17 in. (2.92%)
Evapotranspiration	28.72 in. (71.52%)	28.75 in. (71.60%)	28.74 in. (71.56%)	31.66 in. (78.84%)	28.76 in. (71.61%)
Lateral Drainage	-	9.23 in. (22.97%)	10.92 in. (27.20%)	1.94 in. (4.84%)	10.58 in. (26.36%)
Percolation Through Cover	10.97 in. (27.32%)	1.73 in. (4.30%)	0.037 in. (0.09%)	0.0051 in. (0.013%)	0.0016 in. (0.004%)

AVERAGE DAILY LEACHATE GENERATION RATE (gallons per day)

	Soil Cover	Single Barrier Caps			Composite Cap
	Typical	PADER-Type A	PADER-Type B	ERM VE Cap	RCRA-Type
Unlined Landfill (2.93 acres)	2,390	376	52.6	1.11	0.35
Lined Landfill (2.54 acres)	2,070	326	45.6	0.96	0.30
Total for Site (5.47 acres)	4,460	702	98.2	2.07	0.65

areas at the site). If required for stability or other reasons, a geonet drainage layer will be included in the design for the ERM VE Cap, should this option be considered appropriate.

- Rather than a one- to two-foot thick clay layer with a maximum permeability of 1×10^{-7} cm/sec, as is typically required for primary and/or secondary barrier layers, the ERM VE cap section includes a one-foot thick soil bedding layer with less strict permeability requirements (i.e., on the order of 1×10^{-6} cm/sec). Because of the effectiveness of the 60-mil liner versus thinner liners, this type of soil is adequate to compensate for any damage to the liner, and is typically more available and less expensive to purchase and install than a typical clay barrier with strict permeability requirements. If low-permeability soil is not available in the vicinity of the site, local soil can be amended with bentonite to achieve a lower permeability.
- Based on a map of regional frost depths, the frost penetration depth at the Site has been estimated as approximately 30 inches (*Final Covers on Hazardous Waste Landfills and Surface Impoundments*, EPA/530-SW-89-047). Although compacted clay liners are susceptible to damage and increased permeability as a result of frost action (EPA/530-SW-89-047), geomembrane liners are generally unaffected by frost action (because they do not store water) and low temperatures that may be encountered (based on typical product data). Thus, the 24-inch thick layer of cover soils above the geomembrane liner is adequate for the alternate PADER-type cap and ERM VE cap. The effects of frost action of the soil bedding layer for the ERM VE cap are expected to be insignificant, due to the less-stringent permeability requirements. The typical PADER-type cap and the composite barrier cap include 36 inches of cover soils above the compacted clay liners to provide frost protection.

4.0 *CONCLUSION*

Based on this evaluation, a single barrier cap meets the PADER closure requirements for municipal waste landfills (25 PA Code 273.234) and should be the selected cap design. Variations of the single barrier cap, such as the alternate PADER-type cap and the ERM VE cap, can provide a level of protection (as measured by the reduction in leachate generation) similar to that of composite barrier caps (such as typical RCRA-type caps) but for a lower cost (see Tables B-1, B-2a, B-2b and B-3). Additionally, because the overall thickness (and therefore, weight) of the alternate PADER-type cap and the ERM VE cap is less than that of the other caps considered, potential waste settlement problems following capping are reduced. The thinner cross section also lessens potential concerns related to toe stabilization along the relatively steep western side of the lined fill area.

For the purposes of this evaluation, the alternate PADER-type cap and the ERM VE cap are considered to be potentially appropriate single barrier capping designs. As necessary, the final cap design will be adjusted to address possible concerns associated with relatively steep slopes, potential gas generation, and other factors. Although PADER commented that the ERM VE cap (Alternate 2b) does not contain a drainage layer as required by 25 PA Code 273.234, ERM's analysis in the FS shows that the VE cap is less costly than the PADER cap and provides a greater degree of performance and potential reduction in leachate production. In the remedial design phase of this project, a detailed evaluation of the ERM VE cap will be conducted. At that time it may become evident that portions of the cap could require a drainage layer because of steep slopes. If the design continues to prove to be performance and cost effective, the Settling Companies may request PADER to conduct an equivalency review for the VE cap design.

Table B-1a
PADER-Type Cap
(Clay Barrier and Sand Drain)

Item Description	Quantity	Unit	Unit Cost	Item Cost
Site Preparation, Clearing	6	acre	$4,000	$24,000
Sediment/Storm Water Controls	1	lot	$40,000	$40,000
Surface Grading	4	acre	$2,000	$8,000
12-inch Soil Bedding, imported	9,700	CY	$12	$116,400
12-inch Clay Barrier, imported	9,700	CY	$25	$242,500
Geotextile Filter	287,500	SF	$0.30	$86,300
12-inch Sand Drain, imported	9,700	CY	$14	$135,800
Geotextile Filter	287,500	SF	$0.30	$86,300
18-inch Cover Soil, imported	14,500	CY	$12	$174,000
6-inch Top Soil, imported	4,840	CY	$18	$87,100
Seeding, Mulching	29,000	SY	$0.70	$20,300
Subtotal				$1,020,700
30% Contingency				$306,200
Projected Opinion of Probable Cost*				$1,330,000

* Notes:

(1) Cost represents conceptual evaluation of potential cap construction cost which has been prepared for comparitive purposes. Estimated costs are subject to change based on preliminary and final engineering design efforts.

(2) Costs are for general cap construction only. Other potential components such as waste consolidation, toe stabilization, gas collection, etc. have not been included herein to provide for a more focused comparison of various capping alternatives.

Table B-1b
PADER-Type Cap
(60-mil FML Barrier and Geonet Drain)

Item Description	Quantity	Unit	Unit Cost	Item Cost
Site Preparation, Clearing	6	acre	$4,000	$24,000
Sediment/Storm Water Controls	1	lot	$40,000	$40,000
Surface Grading	4	acre	$2,000	$8,000
12-inch Soil Bedding	9,700	CY	$12	$116,400
Synthetic Liner (60-mil)	287,500	SF	$0.90	$258,750
Drainage Layer (geonet and fabric)	287,500	SF	$0.60	$172,500
18-inch Cover Soil, imported	14,500	CY	$12	$174,000
6-inch Top Soil, imported	4,840	CY	$18	$87,120
Seeding, Mulching	29,000	SY	$0.70	$20,300
Subtotal				$901,070
30% Contingency				$270,321
Total Capital Cost				$1,171,391

Costs are for general cap construction only. Other related components such as waste consolidation, retaining wall, gas collection, fencing, etc. are not included.

Table B-2
ERM VE Cap

Item Description	Quantity	Unit	Unit Cost	Item Cost
Site Preparation, Clearing	6	acre	$4,000	$24,000
Sediment/Storm Water Controls	1	lot	$40,000	$40,000
Surface Grading	4	acre	$2,000	$8,000
12-inch Soil Bedding, imported	9,700	CY	$15	$145,500
Synthetic Liner (60-mil)	287,500	SF	$0.90	$258,800
18-inch Cover Soil, imported	14,500	CY	$12	$174,000
6-inch Top Soil, imported	4,840	CY	$18	$87,100
Seeding, Mulching	29,000	SY	$0.70	$20,300
Subtotal				$757,700
30% Contingency				$227,300
Projected Opinion of Probable Cost*				$985,000

* Notes:
(1) Cost represents conceptual evaluation of potential cap construction cost which has been prepared for comparitive purposes. Estimated costs are subject to change based on preliminary and final engineering design efforts.

(2) Costs are for general cap construction only. Other potential components such as waste consolidation, toe stabilization, gas collection, etc. have not been included herein to provide for a more focused comparison of various capping alternatives.

Table B-3
RCRA-Type Cap

Item Description	Quantity	Unit	Unit Cost	Item Cost
Site Preparation, Clearing	6	acre	$4,000	$24,000
Sediment/Storm Water Controls	1	lot	$40,000	$40,000
Surface Grading	4	acre	$2,000	$8,000
24-inch Clay Barrier, imported	19,400	CY	$25	$485,000
Synthetic Liner (30-mil)	287,500	SF	$0.80	$230,000
12-inch Sand Drain, imported	9,700	CY	$14	$135,800
Geotextile Filter	287,500	SF	$0.30	$86,300
18-inch Cover Soil, imported	14,500	CY	$12	$174,000
6-inch Top Soil, imported	4,840	CY	$18	$87,100
Seeding, Mulching	29,000	SY	$0.70	$20,300
Subtotal				$1,290,500
30% Contingency				$387,200
Projected Opinion of Probable Cost*				$1,680,000

* Notes:

(1) Cost represents conceptual evaluation of potential cap construction cost which has been prepared for comparitive purposes. Estimated costs are subject to change based on preliminary and final engineering design efforts.

(2) Costs are for general cap construction only. Other potential components such as waste consolidation, toe stabilization, gas collection, etc. have not been included herein to provide for a more focused comparison of various capping alternatives.

Attachment B-1
HELP Model Results for Cap Comparison

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   2-FOOT SOIL COVER
   BELL LANDFILL, TOWANDA, PA
   14 OCTOBER 1993

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                              GOOD GRASS

                               LAYER  1
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                      VERTICAL PERCOLATION LAYER
     THICKNESS                          =       6.00 INCHES
     POROSITY                           =       0.5010 VOL/VOL
     FIELD CAPACITY                     =       0.2837 VOL/VOL
     WILTING POINT                      =       0.1353 VOL/VOL
     INITIAL SOIL WATER CONTENT         =       0.2837 VOL/VOL
     SATURATED HYDRAULIC CONDUCTIVITY   =       0.000797999965 CM/SEC


                               LAYER  2
                               --------

                      VERTICAL PERCOLATION LAYER
     THICKNESS                          =      18.00 INCHES
     POROSITY                           =       0.3609 VOL/VOL
     FIELD CAPACITY                     =       0.1638 VOL/VOL
     WILTING POINT                      =       0.0848 VOL/VOL
     INITIAL SOIL WATER CONTENT         =       0.1638 VOL/VOL
     SATURATED HYDRAULIC CONDUCTIVITY   =       0.000036000001 CM/SEC


                        GENERAL SIMULATION DATA
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     SCS RUNOFF CURVE NUMBER            =       74.98
     TOTAL AREA OF COVER                =      100. SQ FT
     EVAPORATIVE ZONE DEPTH             =       24.00 INCHES
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UPPER LIMIT VEG. STORAGE	=	9.5022 INCHES
INITIAL VEG. STORAGE	=	6.3086 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	4.6506 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR ITHACA NEW YORK

MAXIMUM LEAF AREA INDEX	=	3.30
START OF GROWING SEASON (JULIAN DATE)	=	137
END OF GROWING SEASON (JULIAN DATE)	=	278

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
22.20	22.70	32.20	44.50	54.80	64.30
68.80	67.10	60.20	49.60	39.30	27.60

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.80	2.09	2.65	2.37	3.03	4.00
	4.17	4.03	5.43	4.15	2.36	3.07
STD. DEVIATIONS	2.10	0.80	0.63	0.94	0.94	1.09
	2.81	0.59	2.99	1.70	1.22	0.78
RUNOFF						
TOTALS	0.003	0.000	0.001	0.000	0.000	0.000
	0.117	0.000	0.146	0.054	0.001	0.002
STD. DEVIATIONS	0.007	0.000	0.003	0.000	0.000	0.000
	0.263	0.000	0.271	0.118	0.002	0.004
EVAPOTRANSPIRATION						
TOTALS	0.469	0.723	1.759	2.896	3.268	4.645
	4.641	3.617	3.173	1.813	1.199	0.520

STD. DEVIATIONS	0.162	0.193	0.252	0.389	0.963	0.717
	2.146	1.337	0.800	0.203	0.137	0.124

PERCOLATION FROM LAYER 2

TOTALS	1.5963	1.6412	2.2811	0.7109	0.1864	0.0710
	0.1063	0.0024	0.6137	1.4171	0.9156	1.4297
STD. DEVIATIONS	0.9724	1.2146	1.0085	0.4392	0.0755	0.0199
	0.2314	0.0053	1.1013	2.0301	0.7338	1.5189

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.16	(5.757)	335.	100.00
RUNOFF	0.325	(0.303)	3.	0.81
EVAPOTRANSPIRATION	28.722	(3.545)	239.	71.52
PERCOLATION FROM LAYER 2	10.9719	(4.1279)	91.	27.32
CHANGE IN WATER STORAGE	0.139	(1.334)	1.	0.35

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	3.13	26.1
RUNOFF	0.610	5.1
PERCOLATION FROM LAYER 2	0.8080	6.7
SNOW WATER	3.18	26.5

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3504
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0974

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	1.85	0.3084
2	4.43	0.2462
SNOW WATER	0.70	

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AR300564

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SINGLE BARRIER: PADER-TYPE CAP (W/CLAY)
BELL LANDFILL, TOWANDA, PA
14 OCTOBER 1993

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GOOD GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.5010 VOL/VOL
FIELD CAPACITY	=	0.2837 VOL/VOL
WILTING POINT	=	0.1353 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2837 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000797999965 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	18.00 INCHES
POROSITY	=	0.3609 VOL/VOL
FIELD CAPACITY	=	0.1638 VOL/VOL
WILTING POINT	=	0.0848 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1638 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000036000001 CM/SEC

LAYER 3

LATERAL DRAINAGE LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL

WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1053 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.001700000023 CM/SEC
SLOPE	=	15.00 PERCENT
DRAINAGE LENGTH	=	200.0 FEET

LAYER 4

BARRIER SOIL LINER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC

LAYER 5

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4530 VOL/VOL
FIELD CAPACITY	=	0.1901 VOL/VOL
WILTING POINT	=	0.0848 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1901 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000720000011 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	74.98
TOTAL AREA OF COVER	=	100. SQ FT
EVAPORATIVE ZONE DEPTH	=	24.00 INCHES
UPPER LIMIT VEG. STORAGE	=	9.5022 INCHES
INITIAL VEG. STORAGE	=	6.3085 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	13.3554 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR ITHACA NEW YORK

MAXIMUM LEAF AREA INDEX = 3.30
START OF GROWING SEASON (JULIAN DATE) = 137
END OF GROWING SEASON (JULIAN DATE) = 278

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
22.20	22.70	32.20	44.50	54.80	64.30
68.80	67.10	60.20	49.60	39.30	27.60

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.80	2.09	2.65	2.37	3.03	4.00
	4.17	4.03	5.43	4.15	2.36	3.07
STD. DEVIATIONS	2.10	0.80	0.63	0.94	0.94	1.09
	2.81	0.59	2.99	1.70	1.22	0.78
RUNOFF						
TOTALS	0.393	0.072	0.001	0.000	0.000	0.000
	0.117	0.000	0.146	0.054	0.002	0.034
STD. DEVIATIONS	0.878	0.161	0.003	0.000	0.000	0.000
	0.263	0.000	0.271	0.118	0.004	0.076
EVAPOTRANSPIRATION						
TOTALS	0.469	0.723	1.760	2.897	3.268	4.663
	4.651	3.618	3.173	1.813	1.199	0.520
STD. DEVIATIONS	0.162	0.193	0.252	0.389	0.963	0.703
	2.130	1.338	0.801	0.203	0.136	0.124
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	1.1231	1.1428	1.4767	1.6387	1.0532	0.5277
	0.2639	0.1092	0.0698	0.5014	0.6034	0.7157
STD. DEVIATIONS	0.4041	0.4486	0.5803	0.4232	0.2816	0.1444
	0.0887	0.0926	0.1001	0.7499	0.6368	0.5322
PERCOLATION FROM LAYER 4						
TOTALS	0.1982	0.1848	0.2084	0.1739	0.1477	0.1232
	0.1160	0.1068	0.0506	0.0912	0.1360	0.1539

STD. DEVIATIONS	0.1159	0.1022	0.0920	0.0295	0.0113	0.0058
	0.0036	0.0090	0.0379	0.0925	0.1133	0.1321

PERCOLATION FROM LAYER 5

TOTALS	0.1707	0.1695	0.1950	0.1831	0.1699	0.1463
	0.1360	0.1250	0.1021	0.0918	0.1060	0.1331
STD. DEVIATIONS	0.1134	0.1076	0.1100	0.0673	0.0331	0.0167
	0.0097	0.0061	0.0138	0.0160	0.0558	0.0967

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.16	(5.757)	335.	100.00
RUNOFF	0.819	(0.879)	7.	2.04
EVAPOTRANSPIRATION	28.753	(3.498)	240.	71.60
LATERAL DRAINAGE FROM LAYER 3	9.2256	(0.9198)	77.	22.97
PERCOLATION FROM LAYER 4	1.6907	(0.2571)	14.	4.21
PERCOLATION FROM LAYER 5	1.7284	(0.4001)	14.	4.30
CHANGE IN WATER STORAGE	-0.368	(4.292)	-3.	-0.92

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	3.13	26.1
RUNOFF	0.610	5.1
LATERAL DRAINAGE FROM LAYER 3	0.0859	0.7
PERCOLATION FROM LAYER 4	0.0137	0.1
HEAD ON LAYER 4	36.3	
PERCOLATION FROM LAYER 5	0.0130	0.1
SNOW WATER	3.18	26.5

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3959

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0974

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	1.85	0.3084
2	4.44	0.2465
3	1.26	0.1053
4	5.16	0.4300
5	2.23	0.1861
SNOW WATER	0.70	

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SINGLE BARRIER: PADER-TYPE CAP (W/60-MIL FML AND GEONET DRAIN)
BELL LANDFILL, TOWANDA, PA
15 JUNE 1994

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GOOD GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.5010 VOL/VOL
FIELD CAPACITY	=	0.2837 VOL/VOL
WILTING POINT	=	0.1353 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2837 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000797999965 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	18.00 INCHES
POROSITY	=	0.3609 VOL/VOL
FIELD CAPACITY	=	0.1638 VOL/VOL
WILTING POINT	=	0.0848 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1638 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000036000001 CM/SEC

LAYER 3

LATERAL DRAINAGE LAYER

THICKNESS	=	0.20 INCHES
POROSITY	=	0.8000 VOL/VOL
FIELD CAPACITY	=	0.0400 VOL/VOL

WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0400 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	25.000000000000 CM/SEC
SLOPE	=	15.00 PERCENT
DRAINAGE LENGTH	=	200.0 FEET

LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4530 VOL/VOL
FIELD CAPACITY	=	0.1901 VOL/VOL
WILTING POINT	=	0.0848 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4530 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000720000011 CM/SEC
LINER LEAKAGE FRACTION	=	0.00010000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	74.98
TOTAL AREA OF COVER	=	100. SQ FT
EVAPORATIVE ZONE DEPTH	=	24.00 INCHES
UPPER LIMIT VEG. STORAGE	=	9.5022 INCHES
INITIAL VEG. STORAGE	=	6.3077 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	10.0946 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR ITHACA NEW YORK

MAXIMUM LEAF AREA INDEX	=	3.30
START OF GROWING SEASON (JULIAN DATE)	=	137
END OF GROWING SEASON (JULIAN DATE)	=	278

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
22.20	22.70	32.20	44.50	54.80	64.30
68.80	67.10	60.20	49.60	39.30	27.60

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.80	2.09	2.65	2.37	3.03	4.00
	4.17	4.03	5.43	4.15	2.36	3.07
STD. DEVIATIONS	2.10	0.80	0.63	0.94	0.94	1.09
	2.81	0.59	2.99	1.70	1.22	0.78
RUNOFF						
TOTALS	0.003	0.000	0.001	0.000	0.000	0.000
	0.117	0.000	0.146	0.054	0.001	0.002
STD. DEVIATIONS	0.007	0.000	0.003	0.000	0.000	0.000
	0.263	0.000	0.270	0.117	0.002	0.004
EVAPOTRANSPIRATION						
TOTALS	0.469	0.723	1.762	2.900	3.269	4.642
	4.639	3.617	3.174	1.816	1.203	0.521
STD. DEVIATIONS	0.163	0.194	0.253	0.390	0.965	0.719
	2.146	1.337	0.800	0.204	0.136	0.124
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	1.5840	1.6432	2.2756	0.7099	0.1824	0.0671
	0.1035	0.0023	0.6049	1.4171	0.9096	1.4234
STD. DEVIATIONS	0.9607	1.2267	1.0001	0.4400	0.0764	0.0200
	0.2258	0.0052	1.0940	2.0349	0.7321	1.5183
PERCOLATION FROM LAYER 4						
TOTALS	0.0045	0.0041	0.0046	0.0044	0.0044	0.0040
	0.0011	0.0001	0.0003	0.0025	0.0035	0.0036
STD. DEVIATIONS	0.0001	0.0002	0.0001	0.0001	0.0001	0.0002
	0.0017	0.0003	0.0006	0.0023	0.0020	0.0020

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)	PERCENT

PRECIPITATION	40.16	(5.757)	335.	100.00
RUNOFF	0.325	(0.303)	3.	0.81
EVAPOTRANSPIRATION	28.736	(3.548)	239.	71.56
LATERAL DRAINAGE FROM LAYER 3	10.9231	(4.1145)	91.	27.20
PERCOLATION FROM LAYER 4	0.0371	(0.0065)	0.	0.09
CHANGE IN WATER STORAGE	0.137	(1.331)	1.	0.34

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	3.13	26.1
RUNOFF	0.610	5.1
LATERAL DRAINAGE FROM LAYER 3	0.9014	7.5
PERCOLATION FROM LAYER 4	0.0002	0.0
HEAD ON LAYER 4	7.1	
SNOW WATER	3.18	26.5

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3525

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0974

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	1.85	0.3084
2	4.43	0.2459
3	0.01	0.0400
4	5.44	0.4530

SNOW WATER 0.70

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SINGLE BARRIER: ERM VALUE-ENGINEERED CAP
BELL LANDFILL, TOWANDA, PA
14 OCTOBER 1993

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GOOD GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.5010 VOL/VOL
FIELD CAPACITY	=	0.2837 VOL/VOL
WILTING POINT	=	0.1353 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2837 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000797999965 CM/SEC

LAYER 2

LATERAL DRAINAGE LAYER

THICKNESS	=	18.00 INCHES
POROSITY	=	0.3609 VOL/VOL
FIELD CAPACITY	=	0.1638 VOL/VOL
WILTING POINT	=	0.0848 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1638 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000036000001 CM/SEC
SLOPE	=	15.00 PERCENT
DRAINAGE LENGTH	=	200.0 FEET

LAYER 3

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	12.00 INCHES

POROSITY	=	0.4057 VOL/VOL
FIELD CAPACITY	=	0.3089 VOL/VOL
WILTING POINT	=	0.2099 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4057 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000002100000 CM/SEC
LINER LEAKAGE FRACTION	=	0.00010000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	74.98
TOTAL AREA OF COVER	=	100. SQ FT
EVAPORATIVE ZONE DEPTH	=	24.00 INCHES
UPPER LIMIT VEG. STORAGE	=	9.5022 INCHES
INITIAL VEG. STORAGE	=	9.2197 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	9.5190 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR ITHACA NEW YORK

MAXIMUM LEAF AREA INDEX	=	3.30
START OF GROWING SEASON (JULIAN DATE)	=	137
END OF GROWING SEASON (JULIAN DATE)	=	278

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
22.20	22.70	32.20	44.50	54.80	64.30
68.80	67.10	60.20	49.60	39.30	27.60

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.80	2.09	2.65	2.37	3.03	4.00
	4.17	4.03	5.43	4.15	2.36	3.07

STD. DEVIATIONS	2.10	0.80	0.63	0.94	0.94	1.09
	2.81	0.59	2.99	1.70	1.22	0.78

RUNOFF

TOTALS	1.440	1.023	1.800	0.193	0.004	0.015
	0.388	0.000	0.154	0.815	0.324	0.817
STD. DEVIATIONS	1.698	0.739	1.384	0.394	0.008	0.032
	0.867	0.000	0.271	1.818	0.724	1.340

EVAPOTRANSPIRATION

TOTALS	0.467	0.721	1.754	2.867	3.267	4.642
	7.077	4.139	3.266	1.773	1.171	0.514
STD. DEVIATIONS	0.161	0.191	0.249	0.388	1.053	0.627
	1.121	1.908	0.763	0.202	0.128	0.120

LATERAL DRAINAGE FROM LAYER 2

TOTALS	0.3065	0.2926	0.3139	0.2538	0.1831	0.1023
	0.0440	0.0063	0.0123	0.0987	0.1274	0.2024
STD. DEVIATIONS	0.0336	0.0230	0.0101	0.0257	0.0547	0.0426
	0.0410	0.0136	0.0261	0.1415	0.1456	0.1515

PERCOLATION FROM LAYER 3

TOTALS	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005
	0.0003	0.0001	0.0000	0.0003	0.0004	0.0005
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0001	0.0002	0.0001	0.0003	0.0003	0.0003

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.16	(5.757)	335.	100.00
RUNOFF	6.974	(3.147)	58.	17.37
EVAPOTRANSPIRATION	31.659	(3.227)	264.	78.84
LATERAL DRAINAGE FROM LAYER 2	1.9434	(0.3883)	16.	4.84
PERCOLATION FROM LAYER 3	0.0051	(0.0009)	0.	0.01
CHANGE IN WATER STORAGE	-0.424	(2.024)	-4.	-1.05

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	3.13	26.1
RUNOFF	2.279	19.0
LATERAL DRAINAGE FROM LAYER 2	0.0127	0.1
PERCOLATION FROM LAYER 3	0.0000	0.0
HEAD ON LAYER 3	24.2	
SNOW WATER	3.18	26.5

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3959

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0974

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	1.85	0.3084
2	4.54	0.2522
3	4.87	0.4057
SNOW WATER	0.70	

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COMPOSITE BARRIER: RCRA-TYPE CAP
BELL LANDFILL, TOWANDA, PA
14 OCTOBER 1993

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GOOD GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.5010 VOL/VOL
FIELD CAPACITY	=	0.2837 VOL/VOL
WILTING POINT	=	0.1353 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2837 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000797999965 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	18.00 INCHES
POROSITY	=	0.3609 VOL/VOL
FIELD CAPACITY	=	0.1638 VOL/VOL
WILTING POINT	=	0.0848 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1638 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000036000001 CM/SEC

LAYER 3

LATERAL DRAINAGE LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL

WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1053 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.001700000023 CM/SEC
SLOPE	=	15.00 PERCENT
DRAINAGE LENGTH	=	200.0 FEET

LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC
LINER LEAKAGE FRACTION	=	0.00100000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	74.98
TOTAL AREA OF COVER	=	100. SQ FT
EVAPORATIVE ZONE DEPTH	=	24.00 INCHES
UPPER LIMIT VEG. STORAGE	=	9.5022 INCHES
INITIAL VEG. STORAGE	=	6.3083 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	16.2342 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR ITHACA NEW YORK

MAXIMUM LEAF AREA INDEX	=	3.30
START OF GROWING SEASON (JULIAN DATE)	=	137
END OF GROWING SEASON (JULIAN DATE)	=	278

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
22.20	22.70	32.20	44.50	54.80	64.30
68.80	67.10	60.20	49.60	39.30	27.60

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.80	2.09	2.65	2.37	3.03	4.00
	4.17	4.03	5.43	4.15	2.36	3.07
STD. DEVIATIONS	2.10	0.80	0.63	0.94	0.94	1.09
	2.81	0.59	2.99	1.70	1.22	0.78
RUNOFF						
TOTALS	0.470	0.126	0.001	0.000	0.000	0.000
	0.117	0.000	0.146	0.054	0.004	0.255
STD. DEVIATIONS	1.052	0.281	0.003	0.000	0.000	0.000
	0.263	0.000	0.271	0.118	0.009	0.570
EVAPOTRANSPIRATION						
TOTALS	0.469	0.723	1.760	2.897	3.268	4.663
	4.654	3.618	3.173	1.814	1.200	0.520
STD. DEVIATIONS	0.162	0.193	0.252	0.389	0.964	0.703
	2.125	1.338	0.801	0.203	0.136	0.124
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	1.2264	1.2473	1.4226	1.6953	1.3601	0.7509
	0.4420	0.2553	0.1787	0.5737	0.6281	0.8037
STD. DEVIATIONS	0.3840	0.4465	0.2319	0.3861	0.5008	0.2683
	0.1574	0.1205	0.0935	0.7233	0.5589	0.5513
PERCOLATION FROM LAYER 4						
TOTALS	0.0002	0.0001	0.0002	0.0002	0.0001	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
STD. DEVIATIONS	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)	PERCENT

PRECIPITATION	40.16	(5.757)	335.	100.00
RUNOFF	1.173	(1.175)	10.	2.92
EVAPOTRANSPIRATION	28.759	(3.493)	240.	71.61
LATERAL DRAINAGE FROM LAYER 3	10.5841	(0.9261)	88.	26.36
PERCOLATION FROM LAYER 4	0.0016	(0.0002)	0.	0.00
CHANGE IN WATER STORAGE	-0.360	(3.987)	-3.	-0.90

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	3.13	26.1
RUNOFF	0.962	8.0
LATERAL DRAINAGE FROM LAYER 3	0.0859	0.7
PERCOLATION FROM LAYER 4	0.0000	0.0
HEAD ON LAYER 4	36.3	
SNOW WATER	3.18	26.5

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3959
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0974

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	1.85	0.3084
2	4.44	0.2464
3	1.29	0.1075
4	10.32	0.4300

SNOW WATER 0.70

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Appendix C
Cost Estimates

1.0 INTRODUCTION

This appendix presents preliminary cost estimates for the remedial alternatives developed in the FS. It should be noted that the estimated costs presented herein are engineering opinions of probable costs that have been developed to provide general order-of-magnitude estimates for planning and comparison purposes. More detailed design parameters and estimated costs will be established for the selected remedial alternative during the remedial design phase.

2.0 GENERAL APPROACH

The preliminary cost estimates presented on the attached Tables C-1, C-2a, C-2b and C-3 have been developed based upon a number of assumptions which include the following:

- Unless otherwise specified, quantities are estimated from site maps, figures, previous records, and engineering judgment.
- Unit costs are from recent contractor's bids, specialty contractor's quotes, published cost data with site-specific adjustments, and/or similar project experience.
- The indirect construction cost was assumed to be 15 percent of the direct construction cost. The indirect construction items include mobilization, demobilization, field offices, traffic control, health and safety, insurance, construction management, and other indirect costs not explicitly listed.
- A discount rate of 5 percent after inflation was assumed for the present worth analysis of the operation and maintenance (O&M) costs. Capital costs are based on construction in the near future, and do not account for inflation should the start of the Remedial Action be delayed substantially. A 30-year O&M period was assumed for site maintenance and monitoring, and six 5-year reviews by the EPA were assumed during the 30-year O&M period.

3.0 EXPLANATION OF COSTS

In general, quantities and values that serve as the basis for the cost estimates are as presented on the attached tables (Tables C-1, C-2a, C-2b and C-3). Supporting explanations for some of the items are presented in the following subsections.

3.1 *General Components*

- The estimated costs for all alternatives include long-term ground water monitoring. Costs for ground water monitoring assume quarterly sampling of the on-site wells for the first year following closure. For the No-Action alternative, it has been assumed that, following the first year, the monitoring frequency can be reduced to semi-annually, and the sampling parameter list can be reduced to a more focused list of indicator parameters (thus decreasing costs). The capping alternatives include quarterly sampling of on-site ground water and annual sampling of nearby residential wells for the first five years following closure. For these capping alternatives, the monitoring frequency is assumed to be reduced to annual sampling of ground water and bi-annual sampling (i.e., every other year) of residential wells for years 6 through 30.
- All alternatives include semi-annual site inspections and inspection reports. It is assumed that gas monitoring will be conducted, at a minimum, during site inspections and ground water sampling events.

3.2 *Alternative 1 - No Action (Table C-1)*

- No additional capital expenditure is projected for this alternative.

3.3 *Alternatives 2A and 2B - Single Barrier Cap (Tables C-2a and C-2b)*

- All capping alternatives (Tables C-2a, C-2b and C-3) assume the excavation of isolated areas of contaminated soils and placement within the existing fill areas. To achieve the desired final grades for the caps, the excavation/consolidation of materials currently within the fill areas has also been assumed.
- The capping alternatives assume the off-site disposal of miscellaneous materials from the debris area and the drum area. The estimated costs assume that these materials can be recycled and/or disposed as solid waste.
- The unit cost for the single barrier cap options 2A (Alternate PADER-Type Cap) and 2B (ERM VE Cap) were taken from the appropriate estimated cap construction costs presented in Appendix B, without contingencies.
- All capping alternatives include passive gas collection systems and gas migration monitoring. The actual need to include these components in the remedy will be determined during the final design.

- Leachate system upgrade costs for all capping alternatives (Tables C-2a, C-2b and C-3) include replacement of the damaged leachate collection drain for the unlined fill area, replacement of the leachate collection tank for each of the fill areas, and associated pipes, pumps, level controls, etc.

- The rate of leachate generation was generally estimated from the rate of percolation through the various caps presented in Appendix B. Based on the infiltration rate estimated in Appendix B for a soil cover, the current leachate generation rate from both fill areas is estimated as approximately 4,500 gallons per day. Based on the infiltration rate estimated for the modified PADER-Type Cap and the ERM VE Cap, leachate generation from both fill areas will virtually cease (e.g., a 99.95% reduction to approximately 2 gallons per day for the ERM VE Cap) immediately following cap construction.

  Although leachate generation is expected to virtually cease following cap construction, free-draining leachate present within the fill area at the time of capping will continue to drain from the fill areas until an equilibrium condition is reached. In general, the rate of leachate draining from the fill areas will be large at first, and will then decline over time until the rate of leachate draining is essentially equal to the rate of infiltration through the cap (e.g., estimated as only 2 gallons per day for the ERM VE Cap).

  For cost estimating purposes, an attempt has been made to estimate the potential volume of leachate that will drain from the fill areas following capping. This leachate will be collected in the leachate collection drains and tanks for subsequent treatment and/or disposal. It is assumed that the volume of leachate draining from the fill areas is equal to the volume of leachate collected in the leachate collection system.

  The HELP Model (Version 2.05, Schroeder, et al., 1989) was used to estimate the volume of leachate percolating through the landfilled waste following capping. Although the HELP model is primarily for the comparison of capping options, rather than for predicting actual water budget components (*Design and Construction of RCRA/CERCLA Final Covers*, EPA/625/4-91/025), this model was considered adequate for the purposes of this study. For cost estimating purposes, the model considered the input parameters presented in Appendix B for the ERM VE Cap, along with an underlying waste layer with an average thickness of 12 feet. Due to the lack of site-specific waste information, default values for typical municipal solid waste were used in the model. Based on the relatively large infiltration rate through the existing cap, the initial water content of the waste was estimated as the default value for the field capacity of the waste (i.e., the moisture content at which water can be held in the waste against gravity by surface tension). The HELP model input parameters and results for the first two years following capping are presented in Attachment C-1.

Based on the average annual percolation rates through the waste layer presented in Attachment C-1, the volume of leachate draining from both fill areas is estimated as 260,000 gallons for the first year (i.e., 1.765 inches over a total area of 5.47 acres), and 170,000 gallons for the second year (i.e., 1.126 inches over 5.47 acres). Although the model indicates a steady decrease in the rate of leachate draining over time until it is essentially equal to the percolation rate through the cap (i.e., <800 gal/year), it was assumed for cost estimating purposes that the rate of leachate draining will drop off after the second year and average 20,000 gallons per year for years 3 through 30. To be conservative, and to reflect the marginally superior performance of the composite barrier cap, the leachate volumes for the single barrier capping options were increased to 300,000 gallons for the first year, 200,000 gallons for the second year, and 30,000 gallons for years 3 through 30.

It should be noted that the modeling effort was based on a number of estimates and assumptions, and the model is very idealized and rather sensitive to many of the assumed input parameters (e.g., initial water content). Final determinations and predictions of the rate of leachate draining from the fill areas will be made during the Remedial Design and Remedial Action.

- The cost estimate assumes that excess leachate draining from the fill areas during the initial period following capping (i.e., any collected leachate that may be in excess of what can be stored in the underground leachate collection tanks to be replaced) will be stored in temporary storage tanks placed at the site. It is assumed that such tanks will be made available at the site for approximately the first six months following capping. Following this period, the leachate collection rates are expected to steadily decline such that the underground storage tanks will be adequate to store the collected leachate for a reasonable period of time (see calculations below). All tanks will be equipped with level controls to prevent over-topping.

  For an 8,000 gallon storage tank, and 1.765 inches of percolation from the unlined fill area (2.93 acres) during the first year following capping:

  - average rate of leachate percolation = 380 gal/day
  - (8,000 gal)/(380 gal/day) = 21 days to fill

- The cost estimates assume periodic off-site transportation of collected leachate via tanker truck, and off-site treatment/disposal of the collected leachate at an off-site wastewater treatment facility.
- The actual methods for leachate treatment, disposal, storage, etc. will be determined during the Remedial Design and Remedial Action based on the actual collection rates encountered. Potentially more cost-effective alternatives that may be considered for leachate treatment/disposal include a local POTW and on-site treatment.

3.4 *Alternative 3 - Composite Barrier Cap (Table C-3)*

- The unit cost for the composite barrier cap was based on the estimated cost presented in Appendix B for the RCRA-Type Cap, without contingencies.
- Based on the estimated ground water flow rates through the bedrock unit beneath the site, the required ground water collection rate would be 2 gpm. To be conservative, the costs for the ground water collection and treatment system assumes five new ground water recovery wells at a total flow of 4 gpm. The estimated costs assume discharge of the treated water to a nearby stream located to the east of the site.
- Based on the essentially equivalent performance (in regards to infiltration reduction) of the RCRA-Type Cap, the modified PADER-type Cap and ERM VE Cap, costs and assumptions for leachate generation and handling for the composite barrier cap alternative are generally similar to those presented above for the single barrier cap alternatives (Section 3.3, above). If appropriate, the Remedial Design may include the treatment of leachate through the on-site ground water treatment system which is included as a component of this alternative.

Table C-1
Alternative 1 - No Action

Annual O&M Activities	Quantity	Unit	Unit Cost	Item Cost
Site Inspection/Report (2 per year)	20	hr	$70	$1,400
Fence, Road, Cover Maintenance	1	Lot	$1,200	$1,200
Ground Water Sampling (Yr 1)				
Quarterly Sampling	20	hr/Event	$60	$4,800
Laboratory Analysis	12	samples/Event	$1,200	$57,600
Misc. Equipment	4	Lot	$1,400	$5,600
Data Review and Reporting	20	hr/Event	$70	$5,600
Ground Water Sampling (Yr 2 through 30)				
Semi-annual Sampling	20	hr/Event	$60	$2,400
Laboratory Analysis	12	samples/Event	$500	$12,000
Misc. Equipment	2	Lot	$1,400	$2,800
Data Review and Reporting	20	hr/Event	$70	$2,800
Total Annual O&M Cost (Year 1)				**$76,200**
Total Annual O&M Cost (Year 2 through 30)				**$22,600**
Present Worth Cost for Yrs 2 through 30 (i=5%)				$325,900
5-year Reviews Present Worth, $20,000/review (i=5%)				$55,600
Total Present Worth O&M				**$457,700**
Contingency (30%)				$137,300
Projected Opinion of Probable Cost*				**$595,000**

*Notes:

(1) Estimated costs are based on conceptual evaluation of alternative, and have been prepared for comparison purposes. Estimated costs are subject to change based on preliminary and final design efforts.

(2) See attached supporting explanation of cost estimates.

Table C-2a
Alternative 2A - Single Barrier Cap
(PADER-Type w/60 mil liner and geocomposite drain)

Item Description	Quantity	Unit	Unit Cost	Item Cost
Capping				
Upgrade Access Roads	1	Lot	$15,000	$15,000
On-Site Soil/Waste Consolidation	1,000	CY	$15	$15,000
Off-Site Disposal of Scrap/Debris	800	CY	$90	$72,000
Single Barrier Cap	1	Lump Sum	$901,000	$901,000
Passive Gas Collection	1	Lot	$40,000	$40,000
Toe Stabilization	200	LF	$50	$10,000
Repair of Leachate Collection System				
Repair Leachate Collection Line	1,000	FT	$10	$10,000
New Leachate Tanks (8,000 gal)	2	EA	$18,000	$36,000
Misc. Switches, Pumps, Pipes	1	Lot	$20,000	$20,000
Direct Construction Total (DCT)				**$1,119,000**
Indirect Construction (15% of DCT)				$167,850
Construction Total				**$1,286,850**
Permitting & Legal				$50,000
Design & Resident Engineering				$180,000
Total Capital Cost (TCC)				**$1,516,850**
Contingency (30%)				$455,100
Total Present Worth O&M (from next page)				$894,600
Contingency (30%)				$268,400
Projected Opinion of Probable Cost*				**$3,130,000**

*Notes:

(1) Estimated costs are based on conceptual evaluation of alternative, and have been prepared for comparison purposes. Estimated costs are subject to change based on preliminary and final design efforts.

(2) See attached supporting explanation of cost estimates.

Table C-2a (cont.)
Alternative 2A - Single Barrier Cap
O&M Costs

Annual O&M Activities	Quantity	Unit	Unit Cost	Item Cost
Site Inspection/Report (2 per year)	20	hr	$70	$1,400
Fence, Road, Cover Maintenance	1	Lot	$5,000	$5,000
On-Site GW Monitoring (Yr 1 through 5)				
Quarterly Sampling	50	hr/Event	$100	$20,000
Laboratory Analysis	8	samples/Event	$300	$9,600
Data Review and Reporting	10	hr/Event	$75	$3,000
Residential Sampling (Yr 1 through 5)				
Annual Sampling	16	hr/Event	$50	$800
Laboratory Analysis	8	samples/event	$500	$4,000
Data Review and Reporting	10	hr/Event	$75	$750
On-Site GW Monitoring (Yr 6 through 30)				
Annual Sampling	50	hr/Event	$100	$5,000
Laboratory Analysis	8	samples/Event	$300	$2,400
Data Review and Reporting	10	hr/Event	$75	$750
Residential Sampling (Yr 6 through 30)				
Bi-Annual Sampling	16	hr/Event	$50	$400
Laboratory Analysis	8	samples/event	$500	$2,000
Data Review and Reporting	10	hr/Event	$75	$375
Leachate Costs (Yr 1)				
2 Temp. Storage Tanks (20,000 gal)	180	days	$100	$18,000
Leachate Transportation/Disposal	300,000	gallons	$0.40	$120,000
Leachate System O&M	1	Lot	$8,000	$8,000
Leachate Disposal (Yr 2)	200,000	gallons	$0.40	$80,000
Leachate Disposal (Yr 3 through 30)	30,000	gallons	$0.40	$12,000
Leachate System O&M (Yr 2 through 30)	1	Lot	$5,000	$5,000
Total Annual O&M Cost (Year 1)				**$190,550**
Total Annual O&M Cost (Year 2)				**$129,550**
Present Worth Cost for Yr 2 (i=5%)				$117,500
Total Annual O&M Cost (Year 3 through 5)				**$61,550**
Present Worth Cost for Yrs 3 through 5 (i=5%)				$152,000
Total Annual O&M Cost (Year 6 through 30)				**$34,325**
Present Worth Cost for Yrs 6 through 30 (i=5%)				$378,900
5-year Reviews Present Worth, $20,000/review (i=5%)				$55,600
Total Present Worth O&M				**$894,550**

Table C-2b
Alternative 2B - Single Barrier Cap
(ERM VE Cap)

Item Description	Quantity	Unit	Unit Cost	Item Cost
Capping				
Upgrade Access Roads	1	Lot	$15,000	$15,000
On-Site Soil/Waste Consolidation	1,000	CY	$15	$15,000
Off-Site Disposal of Scrap/Debris	800	CY	$90	$72,000
Single Barrier Cap	1	Lump Sum	$757,700	$757,700
Passive Gas Collection	1	Lot	$40,000	$40,000
Toe Stabilization	200	LF	$50	$10,000
Repair of Leachate Collection System				
Repair Leachate Collection Line	1,000	FT	$10	$10,000
New Leachate Tanks (8,000 gal)	2	EA	$18,000	$36,000
Misc. Switches, Pumps, Pipes	1	Lot	$20,000	$20,000
Direct Construction Total (DCT)				**$975,700**
Indirect Construction (15% of DCT)				$146,355
Construction Total				**$1,122,055**
Permitting & Legal				$50,000
Design & Resident Engineering				$180,000
Total Capital Cost (TCC)				**$1,352,055**
Contingency (30%)				$405,600
Total Present Worth O&M (from next page)				$894,600
Contingency (30%)				$268,400
Projected Opinion of Probable Cost*				**$2,920,000**

*Notes:

(1) Estimated costs are based on conceptual evaluation of alternative, and have been prepared for comparison purposes. Estimated costs are subject to change based on preliminary and final design efforts.

(2) See attached supporting explanation of cost estimates.

Table C-2b (cont.)
Alternative 2B - Single Barrier Cap
O&M Costs

Annual O&M Activities	Quantity	Unit	Unit Cost	Item Cost
Site Inspection/Report (2 per year)	20	hr	$70	$1,400
Fence, Road, Cover Maintenance	1	Lot	$5,000	$5,000
On-Site GW Monitoring (Yr 1 through 5)				
Quarterly Sampling	50	hr/Event	$100	$20,000
Laboratory Analysis	8	samples/Event	$300	$9,600
Data Review and Reporting	10	hr/Event	$75	$3,000
Residential Sampling (Yr 1 through 5)				
Annual Sampling	16	hr/Event	$50	$800
Laboratory Analysis	8	samples/event	$500	$4,000
Data Review and Reporting	10	hr/Event	$75	$750
On-Site GW Monitoring (Yr 6 through 30)				
Annual Sampling	50	hr/Event	$100	$5,000
Laboratory Analysis	8	samples/Event	$300	$2,400
Data Review and Reporting	10	hr/Event	$75	$750
Residential Sampling (Yr 6 through 30)				
Bi-Annual Sampling	16	hr/Event	$50	$400
Laboratory Analysis	8	samples/event	$500	$2,000
Data Review and Reporting	10	hr/Event	$75	$375
Leachate Costs (Yr 1)				
2 Temp. Storage Tanks (20,000 gal)	180	days	$100	$18,000
Leachate Transportation/Disposal	300,000	gallons	$0.40	$120,000
Leachate System O&M	1	Lot	$8,000	$8,000
Leachate Disposal (Yr 2)	200,000	gallons	$0.40	$80,000
Leachate Disposal (Yr 3 through 30)	30,000	gallons	$0.40	$12,000
Leachate System O&M (Yr 2 through 30)	1	Lot	$5,000	$5,000
Total Annual O&M Cost (Year 1)				**$190,550**
Total Annual O&M Cost (Year 2)				**$129,550**
Present Worth Cost for Yr 2 (i=5%)				$117,500
Total Annual O&M Cost (Year 3 through 5)				**$61,550**
Present Worth Cost for Yrs 3 through 5 (i=5%)				$152,000
Total Annual O&M Cost (Year 6 through 30)				**$34,325**
Present Worth Cost for Yrs 6 through 30 (i=5%)				$378,900
5-year Reviews Present Worth, $20,000/review (i=5%)				$55,600
Total Present Worth O&M				**$894,550**

Table C-3
Alternative 3 - Composite Barrier Cap

Item Description	Quantity	Unit	Unit Cost	Item Cost
Capping				
Upgrade Access Roads	1	Lot	$15,000	$15,000
On-Site Soil/Waste Consolidation	1,000	CY	$15	$15,000
Off-Site Disposal of Scrap/Debris	800	CY	$90	$72,000
Composite Barrier Cap	1	Lump Sum	$1,290,500	$1,290,500
Passive Gas Collection	1	Lot	$40,000	$40,000
Toe Stabilization	200	LF	$50	$10,000
Repair of Leachate Collection System				
Repair Leachate Collection Line	1,000	FT	$10	$10,000
New Leachate Tanks (8,000 gal)	2	EA	$18,000	$36,000
Misc. Switches, Pumps, Pipes	1	Lot	$20,000	$20,000
Ground Water Treatment System (10 gpm)				
Recovery Wells, 75 feet deep	5	EA	$4,000	$20,000
Mn/Fe Precipitation Unit	1	EA	$120,000	$120,000
GAC Vessel, 1,000 lb	2	EA	$7,500	$15,000
Storage Building	400	SF	$30	$12,000
Misc. Pumps, Piping	1	Lot	$30,000	$30,000
Discharge Piping	1,500	FT	$10	$15,000
Direct Construction Total (DCT)				**$1,720,500**
Indirect Construction (15% of DCT)				$258,075
Construction Total				**$1,978,575**
Permitting & Legal				$100,000
Design & Resident Engineering				$260,000
Total Capital Cost (TCC)				**$2,338,575**
Contingency (30%)				$701,600
Total Present Worth O&M (from next page)				$1,199,200
Contingency (30%)				$359,800
Projected Opinion of Probable Cost*				**$4,600,000**

*Notes:

(1) Estimated costs are based on conceptual evaluation of alternative, and have been prepared for comparison purposes. Estimated costs are subject to change based on preliminary and final design efforts.

(2) See attached supporting explanation of cost estimates.

Table C-3 (cont.)
Alternative 3 - Composite Barrier Cap
O&M Costs

Annual O&M Activities	Quantity	Unit	Unit Cost	Item Cost
Site Inspection/Report (2 per year)	20	hr	$70	$1,400
Fence, Road, Cover Maintenance	1	Lot	$5,000	$5,000
GW System O&M*	1	Lot	$25,000	$25,000
On-Site GW Monitoring (Yr 1 through 5)				
Quarterly Sampling	50	hr/Event	$100	$20,000
Laboratory Analysis	8	samples/Event	$300	$9,600
Data Review and Reporting	10	hr/Event	$75	$3,000
Residential Sampling (Yr 1 through 5)				
Annual Sampling	16	hr/Event	$50	$800
Laboratory Analysis	8	samples/event	$500	$4,000
Data Review and Reporting	10	hr/Event	$75	$750
On-Site GW Monitoring (Yr 6 through 30)				
Annual Sampling	50	hr/Event	$100	$5,000
Laboratory Analysis	8	samples/Event	$300	$2,400
Data Review and Reporting	10	hr/Event	$75	$750
Residential Sampling (Yr 6 through 30)				
Bi-Annual Sampling	16	hr/Event	$50	$400
Laboratory Analysis	8	samples/event	$500	$2,000
Data Review and Reporting	10	hr/Event	$75	$375
Leachate Costs (Yr 1)				
2 Temp. Storage Tanks (20,000 gal)	180	days	$100	$18,000
Leachate Transportation/Disposal	260,000	gallons	$0.40	$104,000
Leachate System O&M	1	Lot	$8,000	$8,000
Leachate Disposal (Yr 2)	170,000	gallons	$0.40	$68,000
Leachate Disposal (Yr 3 through 30)	20,000	gallons	$0.40	$8,000
Leachate System O&M (Yr 2 through 30)	1	Lot	$5,000	$5,000
Total Annual O&M Cost (Year 1)				**$199,550**
Total Annual O&M Cost (Year 2)				**$142,550**
Present Worth Cost for Yr 2 (i=5%)				$129,300
Total Annual O&M Cost (Year 3 through 5)				**$82,550**
Present Worth Cost for Yrs 3 through 5 (i=5%)				$203,900
Total Annual O&M Cost (Year 6 through 30)				**$55,325**
Present Worth Cost for Yrs 6 through 30 (i=5%)				$610,800
5-year Reviews Present Worth, $20,000/review (i=5%)				$55,600
Total Present Worth O&M				**$1,199,150**

Attachment C-1
HELP Model Results for Leachate Generation Estimate

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LEACHATE REDUCTION FOLLOWING PLACEMENT OF ERM VE CAP
BELL LANDFILL, TOWANDA, PA
14 OCTOBER 1993

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GOOD GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.5010 VOL/VOL
FIELD CAPACITY	=	0.2837 VOL/VOL
WILTING POINT	=	0.1353 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2837 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000797999965 CM/SEC

LAYER 2

LATERAL DRAINAGE LAYER

THICKNESS	=	18.00 INCHES
POROSITY	=	0.3609 VOL/VOL
FIELD CAPACITY	=	0.1638 VOL/VOL
WILTING POINT	=	0.0848 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1638 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000036000001 CM/SEC
SLOPE	=	15.00 PERCENT
DRAINAGE LENGTH	=	200.0 FEET

LAYER 3

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	12.00 INCHES

POROSITY	=	0.4057 VOL/VOL
FIELD CAPACITY	=	0.3089 VOL/VOL
WILTING POINT	=	0.2099 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4057 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000002100000 CM/SEC
LINER LEAKAGE FRACTION	=	0.00010000

LAYER 4

VERTICAL PERCOLATION LAYER

THICKNESS	=	144.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2942 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	74.98
TOTAL AREA OF COVER	=	100. SQ FT
EVAPORATIVE ZONE DEPTH	=	24.00 INCHES
UPPER LIMIT VEG. STORAGE	=	9.5022 INCHES
INITIAL VEG. STORAGE	=	4.6506 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	51.8838 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR ITHACA NEW YORK

MAXIMUM LEAF AREA INDEX	=	3.30
START OF GROWING SEASON (JULIAN DATE)	=	137
END OF GROWING SEASON (JULIAN DATE)	=	278

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
22.20	22.70	32.20	44.50	54.80	64.30
68.80	67.10	60.20	49.60	39.30	27.60

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MONTHLY TOTALS FOR YEAR 74

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	1.84	2.39	3.14	2.54	3.88	4.92
	1.24	3.21	4.98	2.08	3.72	3.08
RUNOFF (INCHES)	0.000	0.000	0.000	0.032	0.000	0.055
	0.000	0.000	0.000	0.000	0.000	0.664
EVAPOTRANSPIRATION (INCHES)	0.716	0.980	1.895	2.960	3.655	4.355
	6.767	1.548	3.984	1.849	1.320	0.639
LATERAL DRAINAGE FROM LAYER 2 (INCHES)	0.0001	0.0110	0.0967	0.2431	0.1937	0.1637
	0.0329	0.0000	0.0000	0.0037	0.0209	0.2734
PERCOLATION FROM LAYER 3 (INCHES)	0.0002	0.0002	0.0005	0.0006	0.0006	0.0005
	0.0003	0.0000	0.0000	0.0002	0.0003	0.0006
PERCOLATION FROM LAYER 4 (INCHES)	0.1932	0.1653	0.1737	0.1598	0.1572	0.1452
	0.1435	0.1373	0.1275	0.1266	0.1179	0.1174

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 3 (INCHES)	0.02	2.73	14.25	20.15	18.21	18.06
	6.27	0.00	0.00	0.83	4.79	20.92
STD. DEV. OF DAILY HEAD ON LAYER 3 (INCHES)	0.06	2.22	2.99	1.50	0.50	2.12
	6.24	0.00	0.00	0.80	3.63	3.24

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ANNUAL TOTALS FOR YEAR 74

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	37.02	308.	100.00
RUNOFF	0.751	6.	2.03
EVAPOTRANSPIRATION	30.669	256.	82.84
LATERAL DRAINAGE FROM LAYER 2	1.0391	9.	2.81
PERCOLATION FROM LAYER 3	0.0039	0.	0.01

PERCOLATION FROM LAYER 4	1.7646	15.	4.77
CHANGE IN WATER STORAGE	2.796	23.	7.55
SOIL WATER AT START OF YEAR	51.88	432.	
SOIL WATER AT END OF YEAR	54.68	456.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 75

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	1.44	3.06	2.25	1.24	3.88	4.95
	3.64	4.36	7.75	3.24	1.95	3.22
RUNOFF (INCHES)	0.001	0.107	3.553	0.000	0.019	0.005
	0.000	0.000	0.625	0.002	0.000	0.271
EVAPOTRANSPIRATION	0.383	0.490	1.640	2.314	3.614	5.667
(INCHES)	7.772	3.020	3.785	1.879	1.076	0.340
LATERAL DRAINAGE FROM	0.3006	0.2864	0.3184	0.2260	0.2093	0.1289
LAYER 2 (INCHES)	0.0237	0.0000	0.0019	0.1754	0.2542	0.3188
PERCOLATION FROM	0.0006	0.0006	0.0007	0.0006	0.0006	0.0005
LAYER 3 (INCHES)	0.0003	0.0000	0.0000	0.0005	0.0006	0.0007
PERCOLATION FROM	0.1132	0.0988	0.1059	0.0992	0.0993	0.0932
LAYER 4 (INCHES)	0.0934	0.0907	0.0853	0.0857	0.0807	0.0812

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON	23.03	23.42	23.42	18.88	18.63	16.86
LAYER 3 (INCHES)	4.96	0.00	0.53	17.82	20.70	23.45
STD. DEV. OF DAILY HEAD	0.32	0.78	0.63	1.51	1.37	1.63
ON LAYER 3 (INCHES)	4.12	0.00	1.98	2.98	0.89	0.44

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ANNUAL TOTALS FOR YEAR 75

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	40.98	342.	100.00
RUNOFF	4.582	38.	11.18
EVAPOTRANSPIRATION	31.980	266.	78.04
LATERAL DRAINAGE FROM LAYER 2	2.2437	19.	5.47
PERCOLATION FROM LAYER 3	0.0056	0.	0.01
PERCOLATION FROM LAYER 4	1.1264	9.	2.75
CHANGE IN WATER STORAGE	1.048	9.	2.56
SOIL WATER AT START OF YEAR	54.68	456.	
SOIL WATER AT END OF YEAR	53.85	449.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	1.87	16.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 75

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.64	2.72	2.69	1.89	3.88	4.94
	2.44	3.79	6.36	2.66	2.84	3.15
STD. DEVIATIONS	0.28	0.47	0.63	0.92	0.00	0.02
	1.70	0.81	1.96	0.82	1.25	0.10
RUNOFF						
TOTALS	0.000	0.053	1.776	0.016	0.010	0.030
	0.000	0.000	0.312	0.001	0.000	0.468

STD. DEVIATIONS	0.001	0.075	2.512	0.023	0.013	0.035
	0.000	0.000	0.442	0.001	0.000	0.278

EVAPOTRANSPIRATION

TOTALS	0.550	0.735	1.767	2.637	3.634	5.011
	7.269	2.284	3.885	1.864	1.198	0.489
STD. DEVIATIONS	0.235	0.347	0.181	0.457	0.029	0.928
	0.710	1.040	0.141	0.021	0.173	0.211

LATERAL DRAINAGE FROM LAYER 2

TOTALS	0.1503	0.1487	0.2076	0.2346	0.2015	0.1463
	0.0283	0.0000	0.0009	0.0895	0.1375	0.2961
STD. DEVIATIONS	0.2125	0.1948	0.1568	0.0121	0.0110	0.0246
	0.0065	0.0000	0.0013	0.1214	0.1650	0.0322

PERCOLATION FROM LAYER 3

TOTALS	0.0004	0.0004	0.0006	0.0006	0.0006	0.0005
	0.0003	0.0000	0.0000	0.0004	0.0004	0.0006
STD. DEVIATIONS	0.0003	0.0002	0.0001	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0003	0.0002	0.0000

PERCOLATION FROM LAYER 4

TOTALS	0.1532	0.1320	0.1398	0.1295	0.1283	0.1192
	0.1185	0.1140	0.1064	0.1061	0.0993	0.0993
STD. DEVIATIONS	0.0566	0.0470	0.0480	0.0428	0.0410	0.0368
	0.0354	0.0330	0.0299	0.0289	0.0263	0.0256

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 75

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	39.00	(2.800)	325.	100.00
RUNOFF	2.666	(2.709)	22.	6.84
EVAPOTRANSPIRATION	31.324	(0.927)	261.	80.32
LATERAL DRAINAGE FROM LAYER 2	1.6414	(0.8518)	14.	4.21
PERCOLATION FROM LAYER 3	0.0048	(0.0012)	0.	0.01
PERCOLATION FROM LAYER 4	1.4455	(0.4513)	12.	3.71
CHANGE IN WATER STORAGE	1.922	(1.236)	16.	4.93

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 75

	(INCHES)	(CU. FT.)
PRECIPITATION	2.76	23.0
RUNOFF	0.750	6.2
LATERAL DRAINAGE FROM LAYER 2	0.0123	0.1
PERCOLATION FROM LAYER 3	0.0000	0.0
HEAD ON LAYER 3	24.1	
PERCOLATION FROM LAYER 4	0.0064	0.1
SNOW WATER	2.84	23.6

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3959

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0974

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FINAL WATER STORAGE AT END OF YEAR 75

LAYER	(INCHES)	(VOL/VOL)
1	2.87	0.4777
2	6.64	0.3687
3	4.87	0.4057
4	39.48	0.2742
SNOW WATER	1.87	

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